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Original Research

Ethnopharmacological Study and Antibacterial Activities of Some Plants Used in Traditional Medicine for the Treatment of Diarrheal Diseases in Gabon

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Abstract

The purpose of this work was to develop ethnopharmacological and biological studies of plants used in traditional medicine for the treatment of diarrheal diseases. This study results in scientific data that validates the uses of these plants in traditional medicine. Firstly, ethnopharmacological surveys were conducted with a few traditional healers from the provinces of Estuaire, Haut Ogooué and Woleu-Ntem in Gabon. Next, ethnobotanical data such as percentage of families, species, routes of administration, methods of preparation, parts used and number of plant names were analyzed and summarized. Finally, the antibacterial activities of some plants have been evaluated by diffusion and microdilution methods. Thirty-four (34) traditional healers were interviewed. A total of 90 plant species were identified during this study. They belong to 44 families, the most represented were Leguminoseae (13.33%), Apocynaceae (7.78%), Annonaceae (5.55%), Euphorbiaceae (4.44%) and Anacardiaceae (4.44%). Trees were used more (44.44%) than shrubs (32.22%), herbaceous plants (16.67%) and lianas (6.67%). The drug administration was mainly oral (84.62%) and by the anal route. Decoction and maceration were the two most used methods of preparation. Among identified plants, twenty-seven (27) plant extracts were subjected to microbiological analyzes. Plant extracts tested were active on Gram-negative and Gram-positive bacteria. Cola nitida extracts gave the best antibacterial activity against *Enterococcus faecalis* 103907 CIP. This study identified 90 antidiarrheal plant species and clearly shows the antimicrobial potential of several medicinal species.

Keywords: Ethnopharmacological; Gabon; Anti-diarrheal; Antibacterial activities; Traditional medicine

Introduction

Diarrhea is one of the most common and widespread diseases in the world. It is one of the leading causes of morbidity and mortality [1]. Diarrheal diseases manifest themselves through a wide range of infections, including cholera, typhoid fevers, food poisoning, salmonella, shigellosis, amoebae and other intestinal infections due to specific pathogens [1,2]. They can have several etiological causes; the germs responsible for the infection usually multiply in the intestine and produce toxins. These toxins disrupt the normal function of the intestines and allow a reduction in the ability to transfer water and nutrients to the bloodstream through the intestinal wall, resulting in dehydration

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of the patient [3]. These nutrients are eliminated from the body in the form of frequent and watery stools compared to the individual's usual behavior [4]. Diarrheal diseases are usually transmitted through food, contaminated water and poor hygiene [5]. In 2015, diarrheal diseases caused an estimated 1.4 to 1.8 million deaths [6]; they are among the most important causes of death among children in developing countries [1].
Diarrheal morbidity and mortality are concentrated in low- and middle-income countries, with the highest burden in South Asia and sub-Saharan Africa [7]. Diarrhea is a public health problem due to the proliferation of pathogens. In Gabon, diarrhea is one of the main causes of death in children after malaria, measles and respiratory diseases. They are associated with bioclimatic conditions and household characteristics [8].
The emergence of strains of microorganisms that are multi-resistant to existing drugs increases the interest of medicinal plants. Indeed, many patients are increasingly practicing self-medication with plants [9, 10]. The use of plants to treat oneself is part of the culture and tradition in Africa. It should be noted that for primary health needs, a large part of the African population resorts to traditional medicine whose remedies are essentially plant-based [11,12,13]. As for other pathologies, cases of diarrhea are also treated with traditional medicine.
In Gabon, preliminary work has been done on plants used by the Mitsogho people to treat childhood diarrhea [14]. Our research completes this work by taking into account the Gabonese population in general (ethnic groups, adults and children) on the one hand and by studying the biological effects of the most cited anti-diarrheal plants on the other hand. This study leads to scientific data that validate the uses of these plants in traditional medicine. In this context, this work aims to contribute to the search for solutions for the improvement of the health of the populations by the ethnopharmacological and pharmacological study of the plants used in Gabon in the treatment of diarrheal diseases.

Materials and Methods

Study area

Gabon, located in Central Africa, is crossed by the equator and covers an area of 267,667 km^2. About 800 km of coastline give it access to the Atlantic Ocean and it shares borders to the north with Equatorial Guinea and Cameroon, and to the East and South with the Congo [15]. Dense forest covers more than 80% of its surface, savannahs and natural pastures represent the other forms of vegetation present on its territory. The climate is equatorial with two rainy seasons and two dry seasons. The average annual rainfall is 1,831 mm, varying from 1,400 to 3,800 mm, while temperatures range from 21 to 28°C. Gabon's population, estimated at 1,811,078, is composed of approximately 60 ethnic groups [16,17]. The Fangs (35.5%) are the most numerous. The country is subdivided into nine provinces. The study was conducted in three provinces, including Woleu Ntem, Estuaire and Haut Ogooué (Figure 1).

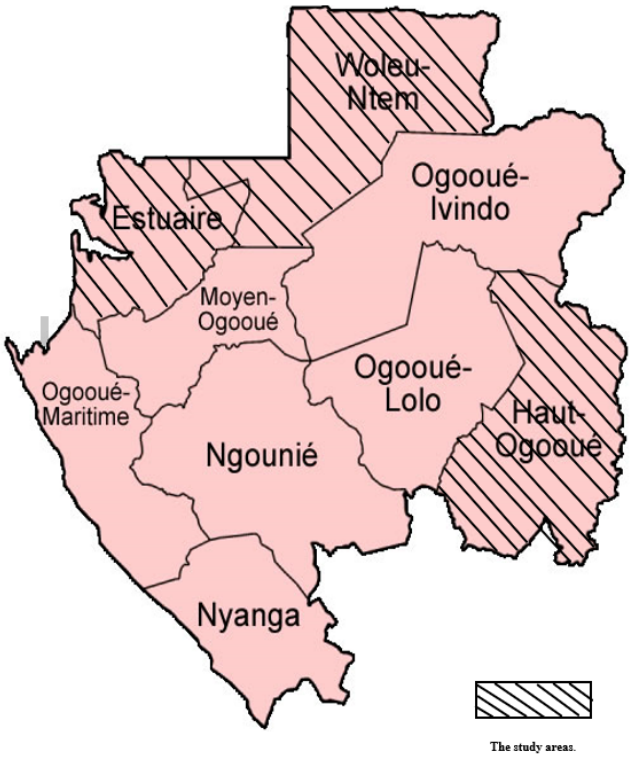

Figure 1. A map showing the location of the study areas

Woleu Ntem is one of Gabon's provinces located in the North of the country. Its capital is Oyem, which, along with the other towns, is home to the vast majority of the province's 155,000 inhabitants [17]. The equatorial forest occupies most of the territory of this province. It is a poorly industrialized region that produces cocoa and rubber. This region is occupied by several practitioners who have the reputation of being very effective in traditional medicine.
The Estuaire province is the first province of the Gabonese Republic. It is located in the Western part of Northern Gabon. This province is the most popular, it includes the country's capital Libreville, the most popular city in Gabon, with about 703,939 inhabitants in 2013, among the 1,811,078 inhabitants of the whole country [16,17]. It is a very cosmopolitan area where traditional healers are concentrated.
The province of Haut-Ogooué is located in the Southeast of Gabon. It is a mountainous area with an altitude that varies between 400 and 600 m above sea level. The capital of Haut-Ogooué province is Franceville with approximately 110,568 inhabitants [17]. In

addition to manganese mining, agriculture provides economic support for the province. The region is occupied by many tribes, including the pygmies, who are well known in the field of traditional medicine.

Data Collection

A survey was carried out among 34 traditional healers and herbalists, men and women, known to the inhabitants. They were preferably consulted individually. The purpose of this consultation was to show respect for the local tradition and to put the traditional therapist in confidence. The study was carried out in four localities in Woleu-Ntem, three localities in the Estuary and three localities in Haut-Ogooué using a survey form. The interviews were conducted between June and December 2015. A first interview was conducted with traditional healers to give them a brief explanation of the objectives of study and importance of the information they were going to provide, in order to obtain their results consent to participate in the study. Each traditional practitioner has given verbal consent certifying his agreement. Data collection was then done through interviews using a semi-structured questionnaire written for the occasion. The questionnaire focused on the following main points: i) the identity of the respondent: name, first names, age and sex; ii) the origin of knowledge: initiation within the family or in another setting, iii) the status of the healer: full-time or part-time healer, iv) illness: the name of the disease in the local language, the symptoms that help to make the diagnosis, v) the plants used in the treatment of the disease, the plant organs used, the method of preparation of recipes and the administration. After interviews with traditional healers, the selected plant species were harvested early in the morning with pruning shears, labeled and transported in anti-ultraviolet plastic bags. Digital photographs of the plant and its characteristic organs were taken. In order to be certain of the plant material used, the parts of plants necessary for identification were taken (flowers, fruits and leaves) and placed in an herbarium. Some data on the habit of the plant were also noted (tree, shrub and grass), as well as all the other information useful for its identification (date and place of sampling). After the harvest, these samples were deposited at the Arboretum of IPHAMETRA in Libreville for the authentication of the plant. The taxonomy has been confirmed based on data available on the plantlist (www.theplantlist.org) website.

Data analysis

Once the fieldwork was completed, all questionnaires were processed for data analysis and transferred to Excel. All parameters, such as methods of preparation, information on the administration of herbal medicines or the number of citations of a species for a specific traditional use were analyzed using descriptive statistics.

Therapeutic indications

Descriptive statistical methods were used to analyze the ethnopharmacological survey data and various quantitative indices, including use value (UV) and relative frequency of citation (RFC). Data were reported in proportions and percentages.

Use value (UV)

Use Value (UV) indicates the relative importance of uses of plant species. It was calculated according to the following formula [18]:

$UV=U/n$

Where “UV” indicates the use value of individual species, “U” represents the number of recorded uses for that species, and “n” represents the number of informants reporting that species. A high UV indicates that there are many reports of plant use, implying that the species is important. UVs are almost zero if there are few reports of its use.

Relative Frequency of Citation (RFC)

The RFC indicates the local importance of each species and is calculated by dividing the frequency of citation (FC), the number of informants certifying the use of the species, by the total number of informants contributing to the survey (N), without taking into account the categories of use. The FC was obtained using the following formula: FC = (number of citations of a particular species / total number of citations of all species) × 100 [19].

$RFC = FC / N (0 < RFC < 1)$

Selection and processing of the plant material

The most cited plants in the field survey were selected for biological activities. The plant samples were freeze-dried, powdered, kept at ambient temperature, and protected from light. Each sample (20 g) were mixed with 250 mL of suitable solvents [water (100%); water-acetone (30:70, v/v); water-ethanol (30:70, v/v)]. The water extracts were boiled for 60 min. All the extracts were filtered and concentrated. The concentrates were lyophilized and stored in sterile vials at 4°C.

Microbial strains

Five (5) bacterial strains including four (4) references and one (1) clinical were used in our study. These are strains recommended by National Committee for Clinical Laboratory Standards (NCCLS) for sensitivity studies. Most of the species used in this study are frequently involved with diarrhea in Gabon. The reference strains used are: *Escherichia coli* 105182

CIP, *Staphylococcus aureus* ATCC 25293 BHI, *Enterococcus faecalis* 103907 CIP and *Shigella dysenteriaee* 5451 CIP. The strains obtained in freeze-dried forms were subcultured in Mueller Hinton broth (Liofilchem, Italy) and kept for the duration of the work by successive subcultures. The clinical strain (Salmonella enterica) is the isolated strain at National Laboratory of Public Health (Libreville). All strains were cultured at 37°C.

Positive and negative control

Gentamicin, Ampicillin, Amoxicillin; Doxycycline and Tetracycline were used as positive control for the test bacterial strains. Sterilized distilled water and dimethyl sulfoxide were used as negative control.

Antibacterial susceptibility testing

Disc diffusion method was used to study susceptibility of bacteria against plant extracts [20]. Bacteria were grown in Muller Hinton broth (Liofilchem, Italy) for 18 to 24 h. Each culture was then suspended in a sodium chloride solution (NaCl, 0.9%) to reach turbidity equivalent to that of the 0.5 MacFarland standard [21]. Extracts were diluted in dimethyl sulfoxide to 100 mg/mL. Previously each extract (10 µL) was loaded onto each filter paper disc (Whatman No. 1). Muller Hinton agar was suspended in distilled water, heated until complete dissolution and was autoclaved at 121°C and then poured into Petri dishes. The discs were placed on cultures and antimicrobial activity was estimated after incubation at 37°C for 24 h, by measuring the diameter of inhibition zone.

Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC)

Minimum Inhibitory Concentrations (MIC) and Minimum Bactericidal Concentrations (MBC) were determined by microdilution method with Muller Hinton broth [22,23]. Briefly, Nutrient broth (100 µL/well) is distributed into wells of a microplate (Nunc). One hundred microliters of extracts are added to first wells of a row and twofold dilution is carried out in other wells. Ninety microliters (90 µL) of nutrient broth and 10 µL of inoculum are added in wells. A range of concentration of extract from 0.0049 to 5 mg/mL was achieved in a total volume of 200 µL to each. The plates are slightly shaken and incubated at 37°C for 24 h; inhibition is assessed by the absence of turbidity in the wells. Wells without extract were used as negative control.

To determine the MBC, 100 µL of from each well demonstrating no visible growth were collected and seeded in Petri dishes containing MHA. The dishes were incubated at 37°C for 24 to 48 h and the number of colonies was counted [24,25].

Results

Ethnopharmacological survey

Informants are central to the success of ethnobotanical studies. Their socio-demographic details (Table 1), such as age, gender and ethnicity provide good survey insight. In this study, 34 traditional healers from various ethnicities (Fang 52.5%, Teke 13.6%, Obamba 10.0%, Myènè 8.7%, Kota 6.5%, Nzébi 5.3% and Punu 3.4%) were interviewed. For this reason, men (69%) were the most numerous compared to women (31%). The highest age bracket is that of 41 to 50 years. The RFC makes it possible to authenticate the frequency of citation of a species of medicinal plant used for various diseases. The RFC was determined for all plant species. The RFC is higher for *Cola nitida* A. Chev (0.0494), *Dacryodes klaineana* (Pierre) H.J.Lam (0.0523) and *Desmodium salicifolium* DC (0.0713) UV is a selection index of potential plant species for a pharmacological study and another guideline for drug development. Use values range from 0.12 to 0.93. Species such as *Alstonia congensis* Engl (0.83), *Anthocleista nobilis* G. Don (0.85), *Carapa klaineana* Pierre (0.89), *Cola nitida* A. Chev. (0.91), *Coula edulis* Baill. (0.89), *Cylicodiscus gabunensis* Harms (0.88), *Dacryodes klaineana* (Pierre) H.J.Lam. (0.92), *Desmodium salicifolium DC*. (0.90), *Zanthoxylum viride* (A.Chev.) P.G.Waterman (0.85), *Mangifera indica* Linn. (0.91), *Morinda lucida* Benth (0.89), *Musanga cecropioides* R. Br. (0.93), *Pseudospondias microcarpa* (A. Rich.) Engl. (0.93), *Pterocarpus soyauxii* Taub (0.88), *Rauvolfia vomitoria* Afzel (0.89) and *Strychnos pungens* Soler. (0.87) have the highest use values (Table 1).

A total of 90 plant species were identified during our study. They belong to 44 families. The most represented families were Leguminoseae (13.33%), Apocynaceae (7.78%), Annonaceae (5.55%), Euphorbiaceae (4.44%) and Anacardiaceae (4.44%). Four families were represented by 3.33% of species each. Eleven and twenty-four families accounted for 1.11% and 2.22% of each species respectively (Table 2). The fields of study are mostly covered by the forest, trees were used more (44.44%) than shrubs (32.22%) and herbaceous plants (16.67%; Figure 2). The limited numbers of species are lianas (6.67%). The methods of drug administration were mainly oral administration (84.62%) and anal route (15.38%; Figure 3). The administration of plants against diarrheal diseases includes several modes of preparation namely decoction, maceration, chewing, mixing and distillation. Decoction and maceration were the two most used methods of preparation (52.22% and 38.89%, respectively). Water is the most used solvent for recipe preparation. The other methods of preparation

used were mastication with a rate of 6.67% followed by the mixture (1.11%) and distillation (1.11% ; Figure 4). Several plant organs are involved in the preparation of these antidiarrheal recipes (Figure 5). This figure shows that trunk bark (42.39%) followed by leaves (34.78%) and roots (13.04%) were the most commonly used parts. The other parts (whole plant, fruit and resin) were used in frequencies below 10%.

Antibacterial activity

The inhibition diameters of water, water-ethanol and water-acetone extracts of *Rauvolfia vomitoria, Alstonia congensis, Pachylobus trimera, Cola nitida, Dacryodes edulis, Desmodium salicifolium, Fagara viridis, Mangifera indica* and *Musanga cecropioides* were summarized in table 3. The plant extracts tested were active on Gram-negative and Gram-positive bacteria. The stem bark extracts of *Cola nitida* gave the best antimicrobial activity with the largest diameters of inhibition on the majority of bacterial strains tested. *Rauvolfia vomitoria* extracts showed high inhibition diameters on *Escherichia coli* 105182 CIP, *Enterococcus faecalis* 103907 CIP and *Shigella dysenteriaee* 5451 CIP compared to ampicillin. *Shigella dysenteriae* 5451 CIP was more sensitive to water-ethanol extracts of *Dacryodes edulis* (12.0 ± 1.0 mm) and water-acetone extracts of *Fagara viridis* (12.0 ± 0.0 mm) compared to the reference antibiotic (amoxicillin). With the exception of *Escherichia coli* 105182 CIP and *Salmonella enterica*, all bacteria tested showed sensitivity to the twenty-seven (27) plant extracts tested, but the efficacy of each extract in the inhibition was varied from one bacterium to another. Extracts of *Musanga cecropioides* showed little inhibitory effect compared to other plant extracts and reference antibiotics.

Table 1. Socio-demographic details of the interviewed informants

Variables	Category	Percentage (%)
Ethnicities	Fang	52.5
	Teke	13.6
	Obamba	10.0
	Myènè	8.7
	Kota	6.5
	Nzébi	5.3
	Punu	3.4
Age (years)	< 20	7.6
	[20-30]	14.3
	[31-40]	6.1
	[41-50]	39.1
	[51-60]	21.4
	[61-70]	9.3
	> 71	2.2
Gender	Male	69
	Female	31

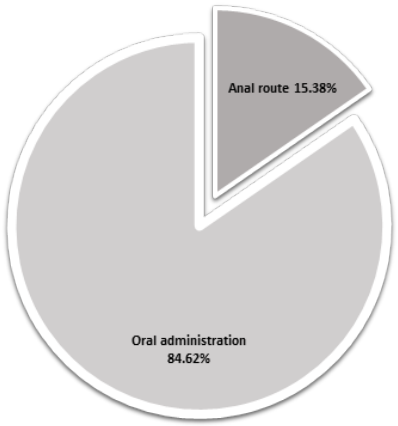

Figure 3. Percentage forms of drug administration

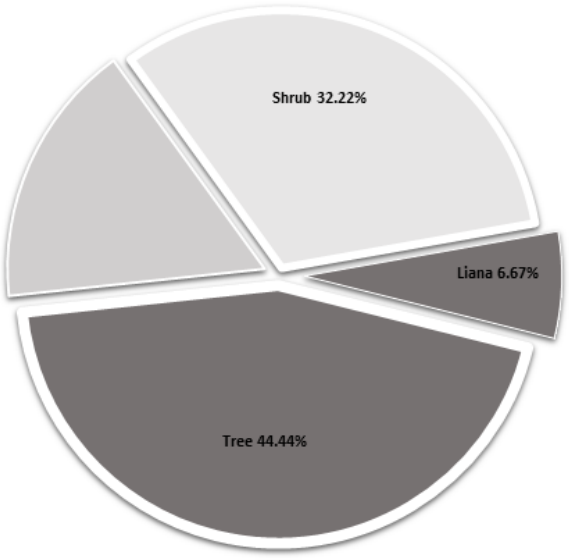

Figure 2. Habit of medicinal plants used in the study area

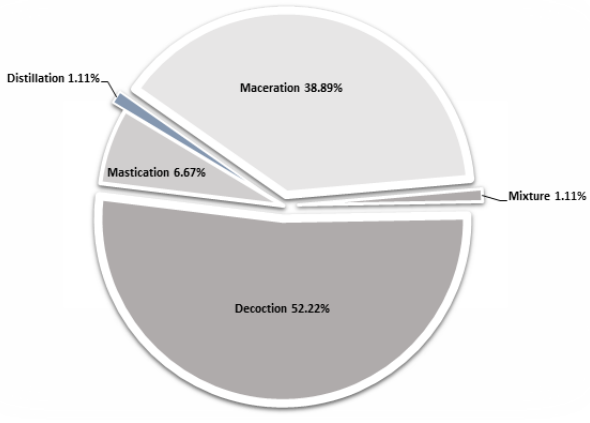

Figure 4. Percentage forms of herbal preparations

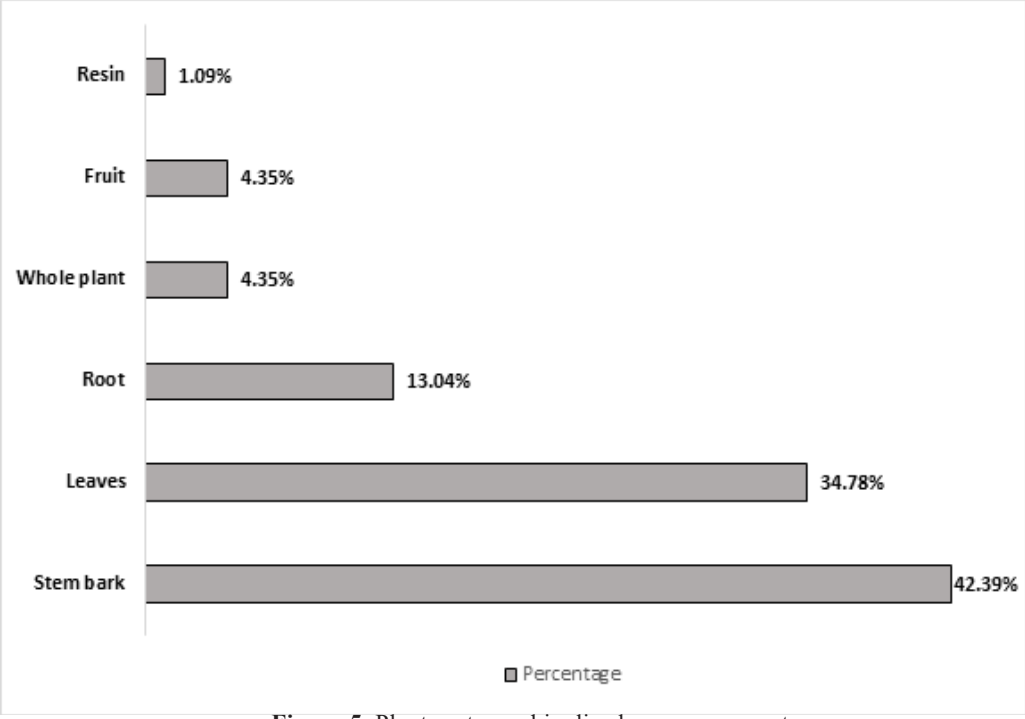

Figure 5. Plant parts used in diarrhea management

Table 2. Plant species used in the treatment of diarrheal diseases in Gabon

Species	Family	Local name	Used part	Preparations	Route of administration	Voucher number	UV	RFC	Nature
Acacia pentagona Hook. f.	Leguminoseae	Kisengele	Stem bark	Maceration	Anal route	SOC / 1	0.13	0.0024	Tree
Aframomum angustifolium K. Schum.	Zingiberaceae	Mpama	Leaves	Decoction	Oral administration	SOC / 2	0.15	0.0024	Herb
Alchornea cordifolia Müll. Arg.	Euphorbiaceae	Nkabi	Stem bark	Maceration	Oral administration	SOC / 3	0.32	0.0071	Shrub
Alstonia congensis Engl.	Apocynaceae	Ekuk	Stem bark	Maceration	Oral administration	SOC / 4	0.83	0.0238	Tree
Anisophyllea buttneri Engl.	Anisophylleaceae	Makaya	Root	Decoction	Oral administration	SOC / 5	0.24	0.0048	Shrub
Annona muricata L.	Annonaceae	Lonkundo	Stem bark	Decoction	Oral administration	SOC / 6	0.18	0.0024	Tree
Annona senegalensis Pers.	Annonaceae	Baraga	Root	Maceration	Oral administration	SOC / 7	0.14	0.0024	Shrub
Anonidium mannii Engl. & Diels	Annonaceae	Kindi	Stem bark	Maceration	Oral administration	SOC / 8	0.26	0.0048	Tree
Anthocleista nobilis G. Don	Gentianaceae	Ayinebe	Root	Decoction	Oral administration	SOC / 9	0.85	0.0238	Tree
Anthocleista schweinfurthii Gilg	Gentianaceae	Ngwaka	Root	Decoction	Anal route	SOC / 10	0.51	0.0119	Tree
Aucoumea klaineana Pierre	Burceraceae	Angouma	Resin	Distillation	Oral administration	SOC / 11	0.13	0.0024	Tree
Bauhinia thonningii Schum.	Leguminoseae	Aboum nzok	Stem bark	Decoction	Oral administration	SOC / 12	0.25	0.0048	Shrub
Bidens pilosa L.	Compositeae	Mondende	Leaves	Maceration	Oral administration	SOC / 13	0.12	0.0024	Herb

Boerhavia diffusa Linn.	Nyctaginaceae	Magbatu	Root	Maceration	Oral administration / Anal route	SOC / 14	0.18	0.0024	Herb
Carapa klaineana Pierre	Meliaceae	Engang	Stem bark	Decoction	Oral administration	SOC / 15	0.89	0.0309	Tree
Carpolobia alba G. Don	Polygalaceae	Molielie	Root	Maceration	Anal route	SOC / 16	0.13	0.0024	Shrub
Catharanthus roseus (L.) G. Don	Apocynaceae	Gbagba	Root	Maceration	Oral administration	SOC / 17	0.26	0.0048	Herb
Ceiba pentandra (Linn.) Gaertii.	Malvaceae	Mofuma	Stem bark	Decoction	Oral administration	SOC / 18	0.21	0.0048	Tree
Celtis tessmannii Rendle	Cannabaceae	Nsaaka	Stem bark	Maceration	Oral administration	SOC / 19	0.80	0.0214	Tree
Celtis zenkeri Engl.	Cannabaceae	Obeng	Leaves	Decoction	Oral administration	SOC / 20	0.21	0.0048	Tree
Chrysanthellum indicum DC.	Compositeae	Sukolambala	Whole plant	Decoction	Oral administration	SOC / 21	0.33	0.0071	Herb
Cissus rubiginosa Planch.	Vitaceae	Gogofio	Leaves	Maceration	Oral administration	SOC / 22	0.68	0.0143	Herb
Cleistopholis patens (Benth.) Engl. & Diels	Annonaceae	Mukuniizu	Stem bark	Decoction	Oral administration	SOC / 23	0.14	0.0024	Tree
Cola nitida A. Chev.	Malvaceae	Banga	Fruit	Decoction	Oral administration	SOC / 24	0.91	0.0594	Tree
Coula edulis Baill.	Olacaceae	Ewémé	Stem bark	Decoction	Oral administration	SOC / 25	0.89	0.0285	Tree
Combretum racemosum P. Beauv.	Combretaceae	Bangabingi	Leaves	Decoction	Oral administration	SOC / 26	0.63	0.0143	Shrub
Craterispermum laurinum (Poir.) Benth.	Rubiaceae	Kitotoko	Stem bark	Decoction	Oral administration	SOC / 27	0.25	0.0048	Shrub
Crinum ornatum (Aiton) Herb.	Amaryllidaceae	Mebamane	Fruit	Maceration	Anal route	SOC / 28	0.13	0.0024	Shrub
Cylicodiscus gabunensis Harms	Leguminoseae	Edum	Stem bark	Decoction	Anal route	SOC / 29	0.88	0.0238	Tree
Dacryodes edulis (G.Don) H.J. Lam	Burseraceae	Nsafu	Stem bark	Decoction	Oral administration	SOC / 30	0.26	0.0048	Tree
Dacryodes klaineana (Pierre) H.J.Lam	Burseraceae	Eba	Stem bark	Decoction	Oral administration	SOC / 31	0.92	0.0523	Tree
Desmodium velutinum (Willd.) DC.	Leguminoseae	Ossama	Leaves	Maceration	Anal route	SOC / 32	0.12	0.0024	Shrub
Desmodium salicifolium DC.	Leguminoseae	Obogbe-nzèn	Leaves	Maceration	Oral administration	SOC / 33	0.90	0.0713	Herb
Diospyros vermoesenii De Wild.	Ebenaceae	Kikele	Stem bark	Decoction	Oral administration	SOC / 34	0.32	0.0071	Shrub
Entandrophragma palustre Staner	Meliaceae	Bosala	Stem bark	Decoction	Oral administration	SOC / 35	0.14	0.0024	Tree

Euphorbia hirta Linn.	Euphorbiaceae	Ngolo	Whole plant	Decoction	Oral administration	SOC / 36	0.13	0.0024	Herb
Zanthoxylum viride (A.Chev.) P.G.Waterman	Rutaceae	Mbudika	Stem bark	Decoction	Oral administration	SOC / 37	0.85	0.0238	Tree
Ficus exasperata Vahl	Moraceae	Sakaya	Leaves	Maceration	Oral administration	SOC / 38	0.51	0.0119	Shrub
Ficus thonningii Blume	Moraceae	Liiitsama	Stem bark	Decoction	Oral administration	SOC / 39	0.23	0.0048	Shrub
Geophila af. afzelii Hiern	Rubiaceae	Rnabata	Leaves	Maceration	Oral administration	SOC / 40	0.12	0.0024	Shrub
Gilbertiodendron dewevrei (de Wild.) J. Léonard	Leguminoseae	Deinba	Stem bark	Maceration	Oral administration	SOC / 41	0.22	0.0048	Tree
Guibourtia Tessmannii (Harms) J. Léonard	Leguminoseae	Oveng	Stem bark	Decoction	Anal route	SOC / 42	0.26	0.0238	Tree
Guibourtia demeusei (Harms) J. Léonard	Leguminoseae	Mbaka	Stem bark	Decoction	Oral administration	SOC / 43	0.55	0.0119	Tree
Hippocratea myriantha Oliv.	Celastraceae	Luamba	Stem bark	Maceration	Oral administration	SOC / 44	0.23	0.0048	Liana
Hugonia platysepala Welw. ex Oliv.	Linaceae	Olondo	Leaves	Maceration	Oral administration	SOC / 45	0.13	0.0024	Shrub
Hymenocardia ulmoides Oliv.	Phyllanthaceae	Kumba	Leaves	Maceration	Anal route	SOC / 46	0.75	0.0190	Shrub
Hymenocardia acida Tul.	Phyllanthaceae	Mungeete	Stem bark	Maceration	Oral administration	SOC / 47	0.66	0.0166	Tree
Iodes africana Welw. ex Oliv.	Icacinaceae	Okusankula	Whole plant	Decoction	Oral administration	SOC / 48	0.44	0.0095	Liana
Klainedoxa gabonensis Pierre.	Irvingiaceae	Okuma	Leaves	Maceration	Oral administration	SOC / 49	0.22	0.0048	Tree
Landolphia owariensis P. Beauv.	Apocynaceae	Lokonda	Stem bark	Maceration	Oral administration	SOC / 50	0.12	0.0024	Liana
Lannea welwitschii (Hiern) Engl.	Anacardiaceae	Rikoiibi	Stem bark	Decoction	Oral administration	SOC / 51	0.22	0.0048	Tree
Lasianthera africana P. Beauv.	Stemonuraceae	Nzumbn	Leaves	Decoction	Oral administration	SOC / 52	0.31	0.0071	Shrub
Mangifera indica Linn.	Anacardiaceae	Andoc-ntangha	Fruit	Maceration	Oral administration	SOC / 53	0.91	0.0357	Shrub
Manniophyton fulvum Müll. Arg.	Euphorbiaceae	Kasa	Leaves	Maceration	Oral administration	SOC / 54	0.53	0.0143	Liana
Microdesmis puberula Hook.f. ex Planch.	Pandaceae	Isisike	Leaves	Decoction	Oral administration	SOC / 55	0.11	0.0024	Shrub
Morinda lucida Benth	Rubiaceae	Akeng	Leaves	Decoction	Oral administration	SOC / 56	0.89	0.0309	Tree
Musa paradisiaca L.	Musaceae	Likemba	Leaves	Maceration	Oral administration	SOC / 57	0.13	0.0024	Herb
Musanga cecropioides R. Br.	Urticaceae	Asèng	Stem bark	Decoction	Anal route	SOC / 58	0.93	0.0523	Tree

	Newbouldia laevis (P. Beauv.) Seem.	Bignoniaceae	Udjuomo	Stem bark	Decoction	Oral administration	SOC / 59	0.44	0.0119	Tree
	Olax latifolia Engl.	Olacaceae	Kikangi	Leaves	Mastication	Oral administration	SOC / 60	0.75	0.0190	Shrub
	Oryza sativa L.	Poaceae	Olès	Fruit	Mastication	Oral administration	SOC / 61	0.53	0.0143	Herb
	Panda oleosa Pierre	Pandaceae	Afan	Stem bark	Decoction	Anal route	SOC / 62	0.46	0.0119	Tree
	Paullinia pinnata L.	Sapindaceae	Songbakele	Root	Decoction	Oral administration	SOC / 63	0.67	0.0166	Tree
	Persea americana Mill.	Lauraceae	Aboka	Leaves	Decoction	Oral administration	SOC / 64	0.36	0.0095	Tree
	Phyllanthus amarus Schumach. & Thonn.	Phyllanthaceae	Kamwanga	Leaves	Mastication	Oral administration	SOC / 65	0.75	0.0214	Herb
	Physalis angulata L.	Solanaceae	Buu	Leaves	Decoction	Oral administration	SOC / 66	0.18	0.0048	Herb
	Plectranthus africanus (Baker ex Scott-Elliot) A.J.Paton	Lamiaceae	Mfyété yambwebwe	Leaves	Decoction	Oral administration	SOC / 67	0.13	0.0024	Shrub
	Piper guineense Schumach. & Thonn.	Piperaceae	Mogbongo	Leaves	Decoction	Anal route	SOC / 68	0.26	0.0071	Liana
	Polyscias guilfoylei (W.Bull) L.H.Bailey	Araliaceae	Agnane	Root	Decoction	Oral administration	SOC / 69	0.14	0.0024	Shrub
	Pseudospondias microcarpa (A. Rich.) Engl.	Anacardiaceae	Nyibu	Stem bark	Decoction	Oral administration	SOC / 70	0.93	0.0475	Tree
	Psidium guajava L.	Myrtaceae	Mapela	Stem bark	Decoction	Oral administration	SOC / 71	0.17	0.0048	Shrub
	Pterocarpus soyauxii Taub.	Leguminosae	Mbeh	Stem bark	Mixture	Anal route	SOC / 72	0.88	0.0357	Tree
	Pycnobotrya nitlda Benth.	Apocynaceae	Nbuete	Leaves	Mastication	Oral administration	SOC / 73	0.15	0.0048	Liana
	Quisqualis latiolata (Jack) Exell	Combretaceae	Ebouma	Leaves	Decoction	Oral administration	SOC / 74	0.47	0.0143	Shrub
	Rauvolfia mannii Stapf	Apocynaceae	Mukankari	Root	Decoction	Oral administration	SOC / 75	0.22	0.0071	Shrub
	Rauvolfia vomitoria Afzel.	Apocynaceae	Tengeguzu	Leaves	Maceration	Oral administration	SOC / 76	0.89	0.0285	Shrub
	Senna occidentalis (L.) Link	Leguminosae	Ebessi	Leaves	Maceration	Oral administration	SOC / 77	0.79	0.0214	Herb
	Senna siamea (Lam.) Irwin & Barneby	Leguminosae	Eposo	Stem bark	Decoction	Oral administration	SOC / 78	0.39	0.0119	Tree
	Solanum americanum Mill.	Solanaceae	Batseki	Leaves	Maceration	Oral administration	SOC / 79	0.33	0.0071	Shrub
	Spilanthes acmella (L.) L.	Compositeae	penangaka	Whole plant	Decoction	Oral administration	SOC / 80	0.47	0.0119	Herb
	Spondias dulcis Parkinson	Anacardiaceae	Makomba	Leaves/ Stem bark	Maceration	Anal route	SOC / 81	0.12	0.0048	Herb

Strychnos pungens Soler.	Loganiaceae	Wumi	Stem bark	Mastication	Oral administration	SOC / 82	0.87	0.0238	Shrub
Syzygium rowlandii Sprague	Myrtaceae	Nkiizu	Stem bark	Decoction	Oral administration	SOC / 83	0.78	0.0214	Tree
Tabernaemontana crassa Benth.	Apocynaceae	Bokulukutu	Stem bark	Maceration	Oral administration	SOC / 84	0.35	0.0119	Tree
Tetrorchidium didymostemon Pax et *K.*Hoffm.	Euphorbiaceae	Mudidi	Leaves	Mastication	Oral administration	SOC / 85	0.12	0.0048	Tree
Tephrosia vogelii Hook. f.	Leguminosae	Mbara	Leaves	Maceration	Oral administration	SOC / 86	0.13	0.0024	Tree
Thomandersia laurifolia (T. Anders ex Benth.) Baill.	Schlegeliaceae	Tié	Root	Decoction	Oral administration	SOC / 87	0.15	0.0048	Shrub
Urena lobata L.	Malvaceae	Nnom-okong	Stem bark/ Root	Maceration	Oral administration	SOC / 88	0.12	0.0071	Tree
Vitex madiensis Oliv.	Lamiaceae	Esuabo	Stem bark	Maceration	Oral administration	SOC / 89	0.63	0.0166	Shrub
Xylopia cupularis Mildbr.	Annonaceae	Assuang	Leaves	Maceration	Oral administration	SOC / 90	0.18	0.0048	Tree

UV : Use Value ; RFC : Relative Frequency of Citation

The extracts were considered bactericidal, those with ratios of MBC / MIC to 1 and bacteriostatic, extracts with ratios greater than 1. The results of MIC and MBC were reported in table 4. MICs and MBCs vary from one bacterium to another. The water-acetone extract of Cola nitida showed a bactericidal effect on strains *Staphylococcus aureus* ATCC 25293 BHI, *Shigella dysenteriae* 5451 CIP and *Salmonella enterica* and a bacteriostatic effect on *Escherichia coli* 105182 CIP and *Enterococcus faecalis* 103907 CIP. Water-ethanol extract of *Cola nitida* and water extract of Mangifera indica were bactericidal on *Escherichia coli* 105182 CIP. Water-ethanol extracts of the leaves of *Rauvolfia vomitoria* and water-ethanol extracts of *Pachylobus trimera* stem bark have a bactericidal action on *Staphylococcus aureus* ATCC 25293 BHI. Water-acetone extracts of *Pachylobus trimera* and *Fagara viridis*; water-ethanol extract of *Alstonia congensis*; and water extract of *Mangifera indica* are bactericidal on strain *Enterococcus faecalis* 103907 CIP. Water-acetone extracts of *Dacryodes edulis* and *Mangifera indica*; and water extract of *Fagara viridis* were bactericidal on *Shigella dysenteriae* 5451 CIP. The majority of *Rauvolfia vomitoria* and *Cola nitida* extracts were bacteriostatic.

Table 3. Inhibition zone diameters (mm) produced by the extracts of some medicinal plants

Plants/Standards	Extracts	Bacteria				
		Escherichia coli 105182 CIP	*Staphylococcus aureus* ATCC 25293 BHI	*Enterococcus faecalis* 103907 CIP	*Shigella dysenteriae* 5451 CIP	*Salmonella enterica*
Rauvolfia vomitoria Afzel. (Leaves)	Water	12.0 ± 0.0	10.0 ± 0.5	10.0 ± 0.0	10.0 ± 1.0	9.0 ± 0.0
	Water-ethanol	12.5 ± 0.0	11.0 ± 0.0	12.0 ± 0.0	12.0 ± 0.0	10.0 ± 1.0
	Water-acetone	13.0 ± 0.5	12.0 ± 0.0	12.0 ± 0.5	13.00 ± 1.0	10 ± 0.0
Alstonia congensis Engl. (Stem bark)	Water	Nd	9.0 ± 0.0	10.0 ± 1.0	8.0 ± 1.0	8.0 ± 1.0
	Water-ethanol	8.5 ± 1.0	8.0 ± 0.0	11.0 ± 1.0	9.0 ± 0.6	Nd
	Water-acetone	9.0 ± 0.0	8.0 ± 1.0	10.0 ± 1.0	8.0 ± 1.0	10 ± 1.0
Pachylobus trimera Guillaum (Stem bark)	Water	Nd	8.0 ± 1.0	9.0 ± 0.3	8.0 ± 0.0	Nd
	Water-ethanol	10.0 ± 1.0	9.0 ± 1.0	11.0 ± 1.0	9.0 ± 0.0	9.0 ± 0.0
	Water-acetone	9.0 ± 1.0	11.0 ± 0.0	11.0 ± 1.5	9.0 ± 0.0	10 ± 1.0

Cola nitida A. Chev. (Stem bark)	Water	11.0 ± 1.0	14.0 ± 1.0	19.0 ± 0.6	10.0 ± 0.5	8.0 ± 0.0
	Water-ethanol	14.0 ± 1.0	17.0 ± 0.5	19.0 ± 1.0	17.0 ± 1.0	15.0 ± 1.0
	Water-acetone	12.5 ± 0.5	18.0 ± 0.0	16.0 ± 1.0	16.0 ± 1.0	14.0 ± 1.5
Dacryodes edulis (G.Don) H.J. Lam (Stem bark)	Water	10.0 ± 1.0	9.0 ± 1.0	10.0 ± 1.0	10.0 ± 1.0	8.0 ± 1.0
	Water-ethanol	8.0 ± 1.0	10.0 ± 1.0	10.0 ± 0.5	12.0 ± 1.0	9.0 ± 0.0
	Water-acetone	9.0 ± 0.0	10.0 ± 0.0	9.0 ± 0.0	11.0 ± 1.0	9.0 ± 1.0
Desmodium salicifolium DC. (Leaves)	Water	Nd	8.0 ± 1.0	8.0 ± 1.0	9.0 ± 0.0	7.0 ± 0.0
	Water-ethanol	10.0 ± 1.0	9.0 ± 1.0	9.0 ± 1.0	8.0 ± 0.0	8.0 ± 0.5
	Water-acetone	10.0 ± 0.0	9.0 ± 1.5	10.0 ± 1.0	9.0 ± 0.0	9.0 ± 0.0
Fagara viridis A. Chev. (Stem bark)	Water	10.0 ± 1.0	9.0 ± 1.0	10.0 ± 1.0	11.0 ± 1.0	8.0 ± 1.0
	Water-ethanol	11.0 ± 1.0	10.0 ± 1.0	11.0 ± 0.0	11.0 ± 0.0	9.0 ± 1.0
	Water-acetone	10.0 ± 1.0	10.0 ± 0.0	11.0 ± 1.0	12.0 ± 0.0	10.0 ± 1.0
Mangifera indica Linn. (Stem bark)	Water	11.0 ± 1.0	10 ± 0.00	11.0 ± 0.5	10.0 ± 0.5	9.0 ± 1.0
	Water-ethanol	10.0 ± 1.0	9.0 ± 0.5	11.0 ± 0.0	10.0 ± 1.0	10.0 ± 1.0
	Water-acetone	10.0 ± 0.0	8.0 ± 0.5	10.0 ± 0.5	11.0 ± 0.0	9.0 ± 1.0
Musanga cecropioides R. Br. (Stem bark)	Water	Nd	8.0 ± 0.0	8.0 ± 0.0	8.0 ± 1.5	7.0 ± 1.0
	Water-ethanol	Nd	9.0 ± 0.0	8.0 ± 0.0	7.0 ± 0.0	7.0 ± 1.0
	Water-acetone	7.0 ± 1.0	9.0 ± 0.0	8.0 ± 1.0	9.0 ± 0.5	9.0 ± 0.0
Standards	Am	Nd	Nd	7.0 ± 1.0	Nd	7.0 ± 0.0
	Amox	14.0 ± 0.0	15.0 ± 0.0	21.5 ± 0.5	9.0 ± 1.00	9.5 ± 1.0
	Gen	17.0 ± 1.0	15.0 ± 0.0	30.0 ± 0.0	24.0 ± 0.5	28.0 ± 1.0
	Te	Nd	17.0 ± 0.0	19.0 ± 0.0	16.0 ± 0.0	16.0 ± 0.3
	Doxy	31.0 ± 0.0	41.0 ± 1.00	40.0 ± 0.0	35.5 ± 1.00	22.0 ± 0.0

Nd = Not determinated; Gen = Gentamicin. Te = Tetracycline; Am = Ampicillin; Amox = Amoxicillin; Doxy = Doxycycline

Table 4. Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of the selected plants

Plants	Extracts (mg/mL)		Bacteria				
			Escherichia coli 105182 CIP	*Staphylococcus aureus* ATCC 25293 BHI	*Enterococcus faecalis* 103907 CIP	*Shigella dysenteriae* 5451 CIP	*Salmonella enterica*
Rauvolfia vomitoria Afzel. (Leaves)	Water	MIC	2.50	5.00	5.00	5.00	>5.0
		MBC	5.00	>5.0	>5.0	>5.0	>5.0
	Water ethanol	MIC	2.50	5.00	2.50	2.50	5.00
		MBC	5.00	5.00	5.00	5.00	>5.0
	Water acetone	MIC	2.50	2.50	2.50	2.50	5.00
		MBC	5.00	5.00	5.00	5.00	>5.0
Alstonia congensis Engl. (Stem bark)	Water	MIC	Nd	>5.0	5.00	>5.0	>5.0
		MBC	Nd	>5.0	>5.0	>5.0	>5.0
	Water ethanol	MIC	>5.0	Nd	5.00	>5.0	Nd
		MBC	>5.0	Nd	5.00	>5.0	Nd
	Water acetone	MIC	>5.0	>5.0	5.00	>5.0	5.00
		MBC	>5.0	>5.0	>5.0	>5.0	>5.0
Pachylobus trimera Guillaum (Stem bark)	Water	MIC	>5.0	>5.0	>5.0	>5.0	Nd
		MBC	>5.0	>5.0	>5.0	>5.0	Nd
	Water ethanol	MIC	5.00	>5.0	5.00	>5.0	>5.0
		MBC	>5.0	>5.0	>5.0	>5.0	>5.0
	Water acetone	MIC	>5.0	5.00	5.00	>5.0	5.00
		MBC	>5.0	5.00	5.00	>5.0	>5.0
Cola nitida A. Chev. (Stem bark)	Water	MIC	>5.0	2.5.	1.25	5.0	>5.0
		MBC	>5.0	5.00	2.50	>5.0	>5.0
	Water ethanol	MIC	2.50	1.25	1.25	1.25	1.25
		MBC	2.50	2.50	2.50	2.50	2.50
	Water acetone	MIC	2.50	2.50	2.50	1.25	2.50
		MBC	5.00	2.50	5.00	1.25	2.50
	Water	MIC	5.00	>5.0	5.00	5.00	>5.0
		MBC	>5.0	>5.0	>5.0	>5.0	>5.0

Dacryodes edulis (G.Don) H.J. Lam (Stem bark)	Water ethanol	MIC	>5.0	5.00	5.00	2.50	>5.0
		MBC	>5.0	>5.0	>5.0	5.00	>5.0
	Water acetone	MIC	>5.0	5.00	>5.0	5.00	>5.0
		MBC	>5.0	>5.0	>5.0	5.00	>5.0
Desmodium salicifolium DC. (Leaves)	Water	MIC	Nd	>5.0	>5.0	Nd	>5.0
		MBC	Nd	>5.0	>5.0	Nd	>5.0
	Water ethanol	MIC	5.00	>5.0	5.00	>5.0	>5.0
		MBC	>5.0	>5.0	>5.0	>5.0	>5.0
	Water acetone	MIC	5.0	>5.0	5.00	>5.0	>5.0
		MBC	>5.0	>5.0	>5.0	>5.0	>5.0
Fagara viridis A. Chev. (Stem bark)	Water	MIC	5.00	>5.0	>5.0	5.00	>5.0
		MBC	>5.0	>5.0	>5.0	5.00	>5.0
	Water ethanol	MIC	5.00	5.00	5.00	2.50	>5.0
		MBC	>5.0	>5.0	>5.0	5.00	>5.0
	Water acetone	MIC	5.00	5.00	5.00	2.50	5.00
		MBC	>5.0	>5.0	5.00	2.50	>5.0
Mangifera indica Linn. (Stem bark)	Water	MIC	5.00	5.00	5.00	5.00	>5.0
		MBC	5.00	>5.0	5.00	>5.0	>5.0
	Water ethanol	MIC	5.00	>5.0	>5.0	5.0	5.00
		MBC	>5.0	>5.0	>5.0	>5.0	>5.0
	Water acetone	MIC	5.00	>5.0	>5.0	5.00	>5.0
		MBC	>5.0	>5.0	>5.0	5.00	>5.0
Musanga cecropioides R. Br. (Stem bark)	Water	MIC	Nd	>5.0	>5.0	>5.0	>5.0
		MBC	Nd	>5.0	>5.0	>5.0	>5.0
	Water ethanol	MIC	Nd	>5.0	>5.0	>5.0	>5.0
		MBC	Nd	>5.0	>5.0	>5.0	>5.0
	Water acetone	MIC	>5.0	>5.0	>5.0	>5.0	>5.0
		MBC	>5.0	>5.0	>5.0	>5.0	>5.0

Nd = Not determinated.

Discussion

The present work has aimed to identify the plants used in the treatment of diarrheal diseases in three provinces of Gabon and to study the antibacterial activities of some selected plants.

Ethnobotanical studies have been conducted in the regions, which looked at plants used to treat opportunistic diseases of HIV/AIDS [26]. With regard to diarrheal diseases, this is the first study of its kind in these areas. The ethnobotanical survey was conducted among 34 traditional healers who were predominantly male seniors. This profile of traditional healers in Gabon is the one observed in most studies of this kind, confirming that the practice of traditional medicine is reserved for mature men [27,28]. The conclusion is that the knowledge of a recipe in traditional medicine is above all a family secret that is transmitted from generation to generation through customs and oral tradition. It is therefore necessary to have a mature age and to have some confidence to have access to the knowledge of this medicine. The present study showed a good diversity of plants used in the treatment of diarrhea in the provinces of Woleu-Ntem, Estuaire and Haut-Ogooue (Gabonese provinces), 90 plant species belonging to 44 families were identified. Other ethnobotanical studies have revealed such diversities of anti-diarrheal plants [26]; Madje et al. [29] found 99 plants belonging to 41 families, Mukungu et al. [30] listed 42 plants grouped into 24 families. The most represented families were Leguminoseae, Apocynaceae and Annonaceae. These results have some similarities with some previous work. In the study by Gbolade et al. [31] the most represented families were the Apocynaceae, other studies show that the Leguminoseae were the most represented [32,33]. The stem bark was the most used organs in the treatment of diarrhea. Other studies have shown that leaves are the most used parts in the treatment of diarrheal diseases [34]. Stem bark, just like leaves, roots, or flowers of plants are frequently used in medicinal preparations, but are the most vulnerable parts of plants. This is why these organs contain more chemical compounds, in the form of biologically active secondary metabolites, synthesized by plants for their defense [35]. Moreover, the great use of the leaves is an advantage for the survival of the plants, because their harvest does not involve the irreversible destruction of the plant, as would have been the use of roots or flowers. The organs have been prepared mainly in the form of decoction. This is explained by the fact that the decoction allows for the collection of the most active ingredients and reduces or cancels the toxic effect of certain recipes [36]. The major limitations of these methods of preparation are non-compliance with rules of asepsis, non-control of dosages and a lack of preservation [13]. The efficacy of the plants mentioned in this study requires the mon-

itoring of transformations in the body (absorption, metabolization and elimination). Their bioavailability can be diminished by absorption by the enzymes during their metabolization. It would then be necessary to study their behavior in the body in order to consider adequate pharmaceutical forms. These preparations were administered orally and by the anal route. This prescription can be explained by the fact that diarrhea is related to microbial infections. The study showed that trees were the most used by traditional healers, this could be explained by the fact that the fields of study are mostly covered by the forest.

In this study, the RFC helps to authenticate the citation frequency of a medicinal plant species used for various diseases [37]. The high value of RFC for some species could be explained by the fact that these taxa are the best known and that the most widespread in the region are therefore the most appropriate.

UV, like the other indices, is a selection index of potential plant species for a pharmacological study with a view to the development of new drugs. UVs for species such as *Alstonia congensis* Engl (0.83), *Anthocleista nobilis* G. Don (0.85), *Carapa klaineana* Pierre (0.89), *Cola nitida* A. Chev. (0.91), *Coula edulis* Baill. (0.89), *Cylicodiscus gabunensis* Harms (0.88), *Dacryodes klaineana* (Pierre) H.J.Lam. (0.92), *Desmodium salicifolium* DC. (0.90), *Zanthoxylum viride* (A.Chev.) P.G.Waterman (0.85), *Mangifera indica* Linn. (0.91), Morinda lucida Benth (0.89), Musanga cecropioides R. Br. (0.93), Pseudospondias microcarpa (A. Rich.) Engl. (0.93), Pterocarpus soyauxii Taub (0.88), *Rauvolfia vomitoria* Afzel (0.89) and *Strychnos pungens* Soler. (0.87) indicate that these plants are used extensively to treat the various diseases indicated in this study. The low UVs recorded for some plants may be due to limited knowledge of the uses of these plants to treat diseases other than cancer.

Bibliographic data on the therapeutic and pharmacological effects of the listed plants indicate that they are generally used in the treatment of microbial diseases, including diarrhea. These plants are used both in Gabon and in other African countries for the treatment of several other diseases or infections that can lead to recovery [38]. The majority of the constituents of these plants also have anti-inflammatory activities which could explain their action against diarrhea. These data justify once more the use of plants by traditional healers in order to eliminate microbial agents or their adverse effects on diarrhea [39]. Ultimately, these therapeutic indications from traditional healers have for the most part only empirical bases. They must be checked in the laboratory by phytopharmacological tests to evaluate the effectiveness of the different plant extracts. It emerged from this work that the most common species used by traditional healers to treat diarrheal diseases are *Rauvolfia vomitoria*, *Alstonia congensis*, *Pachylobus trimera, Dacryodes edulis, Fagara viridis, Cola nitida, Dacryodes klaineana, Desmodium salicifolium, Mangifera indica, Musanga cecropioides, Pseudospondias microcarpa* and *Pterocarpus soyauxii*. Several of these species have been subjected to antibacterial activities to verify their efficiencies.

This study allowed us to carry out the extraction with water, ethanol and acetone of stem bark of *Alstonia congensis*, *Pachylobus trimera*, *Cola nitida*, *Dacryodes edulis*, *Fagara viridis*, *Mangifera indica* and *Musanga cecropioides*; and leaves of *Rauvolfia vomitoria* and *Desmodium salicifolium* in order to evaluate the antibacterial activity of these extracts on the in vitro growth of bacterial reference and clinical strains (*Escherichia coli* 105182 CIP, *Staphylococcus aureus* ATCC 25293 BHI, *Enterococcus faecalis* 103907 CIP, *Shigella dysenteriae* 5451 CIP and Salmonella enterica). The strain sensitivity test showed the presence of antibacterial activity.

Thus, extracts of *Cola nitida* (*C. nitida*) were more active on all bacterial strains tested with diameters ranging from 10 to 19 mm. Our work corroborates with that of Ibezim et al. [40] who demonstrated the good antibacterial activity of the combination of extracts of *C. nitida* and fluoroquinolones on *E. coli*. The antibacterial activities shown by the species of *C. nitida* are also consistent with previous antimicrobial work [41,42,43] where crude extracts of *C. nitida* have been shown to be important inhibitors against the growth of certain bacteria (*Escherichia coli*, *Staphylococcus aureus* and *Shigella dysenteriae*). The water and water-ethanol extracts of *C. nitida* showed the greatest inhibitory activity against *Enterococcus faecalis* 103907 CIP compared to the water-acetone extract. The possible explanation for the difference in activity between the extracts may be the ability of the solvent to solubilize and extract some phytomolecules. *Escherichia coli* 105182 CIP, *Staphylococcus aureus* ATCC 25293 BHI, Enterococcus faecalis 103907 CIP, *Shigella dysenteriae* 5451 CIP and Salmonella enterica were susceptible to *Rauvolfia vomitoria* extracts. Analysis of the experimental data shows that compared to the control, there is a decrease in the germ growth disorder in the test tubes as the concentration of the extract increases.

In the present study, the antibacterial activity against reference and clinical strains may be due to the presence of the bioactive constituents of *Rauvolfia vomitoria* [44]. Previous studies have shown that most of the time the polar extracts of *Rauvolfia vomitoria* possess antibacterial activities [45]. The results show that extracts of *Rauvolfia vomitoria* and *C. nitida* had a high antibacterial activity compared to other plant extracts (*Alstonia congensis*, *Pachylobus trimera*, *Dacryodes edulis*, *Fagara viridis*, *Mangifera indica*, Musanga ce-

cropioides and *Desmodium salicifolium*).
However, the latter had inhibitory activities on the majority of bacterial strains. The studies of Fomogne-Fodjo et al. [46] confirm the antibacterial activity of the stem bark of Musanga cecropioides and the leaves of *Desmodium salicifolium*. Other studies have shown inhibition of *Dacryodes edulis* (essential oil and leaf ethanol extract) against *Escherichia coli* and *Staphylococcus aureus* [47,48]. The leaves of *Mangifera indica* have been reported to possess antibacterial activity against *Escherichia coli* and other bacteria of Enterobacteriaceae family [49,50]. Other studies have shown that methanol extracts of *Mangifera indica* have significant anti-diarrheal activity [51]. These biological activities favor their use in the treatment of microbial infections, especially diarrheal diseases in traditional medicine [39,52,53].

Conclusion

This study shows that of Woleu-Ntem, Estuaire and Haut-Ogooué provinces (Gabon) have an interesting floristic biodiversity in terms of anti-diarrheal plants. In addition, traditional healers in these provinces share many similarities in the use of plant species. Surveys of traditional healers have identified 90 medicinal plants. Of the identified plants, twenty-seven (27) plant extracts were subjected to microbiological in vitro testing. It is interesting, however, to extend this type of study to other parts of the country; this will help to gather as much information as possible about the antidiarrheal medicinal species and to establish complete monographs. It is also essential to study the toxicity of plants by the appropriate cytotoxicity tests so that the use of plants is more scientifically based.

Conflict of Interests

None.

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