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## Ethnobotanical Study of Plants Used in Traditional Treatment of Diarrhoea in Humans and Cattle in Two Regions of Ivory Coast

Karim Tuo<sup>1</sup>, Gbouhoury Eric-Kévin Bolou<sup>2</sup>, Assi Fiacre-Tanguy N'docho<sup>2</sup>, Aurélie Chevillot<sup>3</sup>, Mohamed Mammeri<sup>4</sup>, Isabelle Vallee<sup>3</sup>, Karim Adjou<sup>4</sup>, Offianan André Toure<sup>1</sup>, Bruno Polack<sup>4</sup> and Ronan Jambou<sup>1,5\*</sup>

<sup>1</sup>Pasteur Institute of Côte d'Ivoire, Côte d'Ivoire.

<sup>2</sup>Centre National de Floristique, Côte d'Ivoire.

<sup>3</sup>UMR BIPAR, ANSES, Ecole Nationale Vétérinaire d'Alfort, INRA, Université Paris-Est, Animal Health Laboratory, Maisons-Alfort, F-94700, France.

<sup>4</sup>UMR BIPAR, Ecole Nationale Vétérinaire d'Alfort, ANSES, INRA, Université Paris-Est, Maisons-Alfort, F-94700, France.

<sup>5</sup>Global Health Department, Institute Pasteur Paris, 75015, France.

### Authors' contributions

This work was carried out in collaboration among all authors. Author KT conducted field and laboratory studies and wrote the manuscript. Authors AC, MM and IV participated in laboratory studies and standardized in vitro model. Authors AFTN and GEKB organized field study and plants identification. Author KA standardized in vitro model and reviewed the manuscript. Authors OAT and BP reviewed the manuscript. Author RJ coordinated the project and wrote the manuscript. All authors read and approved the final manuscript.

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### ABSTRACT

**Ethnopharmacological Relevance:** An ethnobotanical survey was conducted in three regions of the country (two rural and one urban), using a questionnaire focussing on anti-diarrheal therapeutic habits.

**Methodology:** Information about the plants has been recorded (local name, organs or part(s) of

\*Corresponding author: E-mail: [rjambou@pasteur.fr](mailto:rjambou@pasteur.fr);

the plant used, therapeutic indications, harvesting methods, methods of administration, side effects, etc.). Collection of the plants was done in collaboration with traditional practitioners and identification of the specimens was conducted at the National Floristic Center (Ivory coast).

During the ethnobotanical survey, twelve traditional healers and nine breeders were interviewed which all declared to treat diarrhoea with plants. During this survey, twenty-seven species belonging to eighteen different families of plants were reported for anti-diarrhoeal use in humans or animals. They were all harvested on the field and a herbarium of each species was prepared in duplicate, one stored at the National Floristic Centre of the Felix Houphouët-Boigny University and the other at the Pasteur Institute of Ivory coast.

**Results:** Decoction was the most common mode of preparation used by practitioners and the oral route remained also the main way of administration of plants by healers. These plants are also used in other countries for the same or other purpose.

**Conclusion:** This study shows that traditional medicinal plants play an important role in the treatment of diarrhoea in Ivory coast. It provides basis for future studies to assess, biological and chemical potential of these plants.

*Keywords: Ethnobotanical survey; medicinal plants; diarrhoea; Ivory Coast.*

## 1. INTRODUCTION

Medicinal plants and traditional medicine play an important role in the population health in tropical countries [1] as conventional medicine is expensive and often inaccessible to disadvantaged populations. Indeed, in West Africa, nearly 80% of the population still use traditional medicine for primary health care and remains faithful to this practice, especially in rural setting [1,2] both in humans and in animals. For example, in the north of Ivory coast, the leaves of certain plant species are given to animals when they have diarrhea. Knowledge on medicinal plants and on their therapeutic effects is transmitted from generation to generation of practitioners [3]. However, safety, efficacy, and mechanisms of actions of these plants are poorly investigated. The use of plants in conventional medicine is experiencing a significant revival of interest in the framework defined by WHO as "Improved Traditional medicine". This is also related to growing resistance of microorganisms against conventional drugs [4]. Practitioners use plants to treat common troubles, among which diarrhoea is one of the most frequent [5]. Diarrhoeal diseases cause about 1.8 million deaths each year worldwide and kill more young children than AIDS, malaria and measles combined [6]. Ninety percent of deaths due to diarrhoea are children under 5 years mostly living in developing countries [7]. Intestinal pathogens are the third leading cause of death for infectious diseases of all ages [8,9] and the fifth leading cause of premature death worldwide [10].

In the field of traditional medicine, plants products are considered to be the most available and inexpensive sources of treatment. This traditional use of plants can provide guidance to start new researches and are considered as invaluable sources of pharmaceuticals [11,12].

The aim of this study was to inventory anti-diarrheal plants used in traditional human and veterinary medicine to lead biochemical analysis. To achieve this goal, an ethnobotanical survey was conducted among traditional healers and cattle breeders in Ivory coast. Plant samples were collected and herbarium prepared and stored at the Pasteur Institute of Ivory coast and at the National Floristic Center of the Félix Houphouët-Boigny University.

## 2. MATERIALS AND METHODS

### 2.1 Study Areas

The study took place in Ivory Coast which is located between 4° and 10° north latitude. The territory of Ivory Coast is about 400 km from the equator on its southern margins and about 1,400 km from the Tropic of Cancer on its northern borders. Globally hot and humid, this location sustains a gradient of climate between equatorial and sub Sahelian ones. Daily temperature is between 16°C and 36°C. The vegetation consists of savannah in the north and forest in the south. For this study, three localities were chosen to explore different climatic and geographical contexts. Lakota and Port-Bouët in Abidjan are

located in the South and Korhogo in the north of the country (Fig. 1). In Port-Bouët, the study was conducted in the slaughterhouses, where herds group from all the south part of the country.

## 2.2 Data Collection

The cross-sectional descriptive study had been conducted in March 2018. The population investigated consists of traditional practitioners or animal healers of the area.

The ethnobotanical survey was conducted using guided oral questioning (Fig. 2). The form included specific questions on the informant (age, sex, therapeutic practice, etc.) and on the medicinal plants used by the informant to control diarrhoea (vernacular name, part used, harvesting methods, preparation method, administration methods, side effects, etc.).

## 2.3 Harvesting Plants and Herbarium Preparation

Harvesting campaign was conducted on the field with the practitioners themselves. When a harvesting site is identified, a systematic hunt was conducted to search for other species. All the sites of collection was GPS geolocated using

a Garmin 66ST Gps. Plant samples were collected in a reasonable manner, which means that the population of the species at the harvest site must not be endangered.

The plants were identified at the harvesting site. For plant identification raising some doubts another examination was conducted at the National Floristic Centre of the Félix Houphouët-Boigny University for definitive identification.

The harvested plant material was carefully cut and dried away from the sun and moisture. Samples were stored in a blotting paper envelope to protect them from moisture. A herbarium board was made for each plant with a sample presenting characteristic elements of the specie (leaves, flowers, fruits or whole plants).

## 3. RESULTS AND DISCUSSION

### 3.1 Results

Three localities were visited (Fig. 1). During the ethnobotanical survey, twelve traditional healers and nine breeders (all men) were interviewed (Fig. 2). Breeders were met in Korhogo, where cattle breeding is frequent and at the Port-Bouet slaughterhouse.

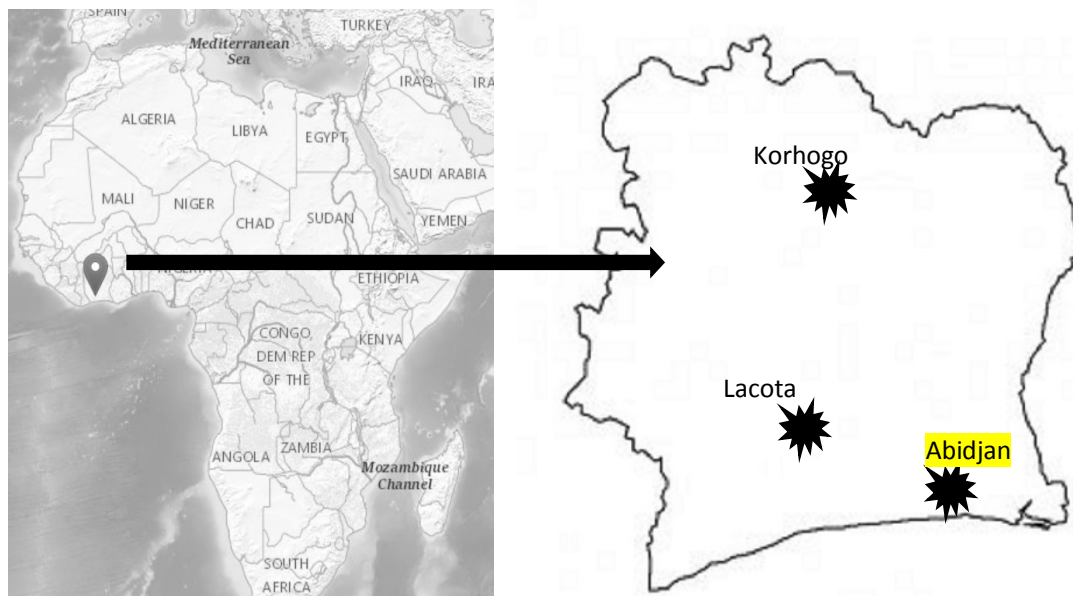


Fig. 1. Site of collection



**Fig. 2. Plant identification and collection**

Both herders and traditional practitioners defined diarrhoea as fluid and repeated stools. In case of diarrhoea, farmers give the leaves to the animals as food. For humans, in case of diarrhoea, plants (leaves, bark and/or roots) are mostly used as decoction and oral administration remains the most frequent way of administration of plant recommended by healers.

The ethnobotanical surveys lead to identification of 27 species of plants belonging to 18 different families (*Bombacaceae*, *Caesalpinaceae*, *Euphorbiaceae*, *Annonaceae*, *Combretaceae*, *Meliantaceae*, *Vitaceae*, *Fabaceae*, *Moraceae*, *Meliaceae*, *Apocynaceae*, *Ochnaceae*, *Acanthaceae*, *Opiliaceae*, *Malvaceae*, *Hippocratéaceae*, *Hymenophyllaceae*, *Boraginaceae*) used to treat diarrhoea in humans and animals (Table 1). The most commonly used family is the *Fabaceae* (5 species) followed by the *Euphorbiaceae* (3 species) and *Caesalpinaceae* (2 species). Some plants are also used to treat several other diseases. A herbarium of each species has been made in duplicate, one of which is kept at the National Floristic Centre of the Felix Houphouët-Boigny University and the other at the Pasteur Institute of Ivory coast.

### 3.2 Discussion

The aim of this study was to identify and collect information on plants used to treat diarrhoea in three areas of Ivory Coast. It was conducted among traditional practitioners and breeders through a series of ethnobotanical surveys. The

virtues of plants are ancestral knowledge and experience accumulated with age [13,14]. Traditional practitioners are the main source of information at the local level and in Africa, it is the oldest people, who hold traditional knowledge. Selection of plants based on ethnobotanical data improves the probability to select active extracts. However, confidence between people is a major factor during this type of study. The time spends for interrogatory, inventory, and the willingness of traditional practitioners to cooperate, are a major factor during data collection. In this study, the investigators had a perfect knowledge of local languages in order to build this confidence with traditional practitioners, which in term did not hesitate to pass on some of their knowledge. This confidence is now well sustained by the “Nagoya” protocol, already signed by Ivory Coast.

The use of medicinal plants is still a major habit in regions where this study was conducted, and this ethnobotanical study lead to identification of a total of 27 plant species used to treat diarrhoea.

In a similar study conducted by Ambe et al., [5] at the markets of Abidjan, much more plants (63 species) were found. However, markets in Abidjan are overflowing with medicinal species from all regions of Ivory coast or from other countries which could explained this difference. Moreover, our way of investigation can provide much more valuable information on the plants and their biotope and allow collection of fresh specimens on the field.

Table 1. Plants used to treat diarrhoea in humans or animals in Ivory Coast

Species	Family	Voucher specimens	Vernacular names	Part used	Use in humans	Use in animals	Geographical coordinates
<i>Adansonia digitata</i>	<i>Bombacaceae</i>	CNF:15935	Sira (dioula)	L	x	x	X(N) 09.27797° Y(W) 005.59039°
<i>Azelia africana</i>	<i>Caesalpiniaceae</i>	CNF:348	Linguè (dioula)	L		x	X(N) 09.54775° Y(W) 005.69985°
<i>Alchornea cordifolia</i>	<i>Euphorbiaceae</i>	CNF:215	Djeka (baoulé)	L	x		X(N) 06.08909° Y(W) 005.68543°
<i>Annona senegalensis</i>	<i>Annonaceae</i>	CNF:903	Damourigue (senoufo)	L, R	x		X(N) 09.49859° Y(W) 005.60349°
<i>Anogeissus leiocarpus</i>	<i>Combretaceae</i>	CNF:3075	Kodjolé (peulh) Nanganatigue(senoufo) Kèrèkètè (dioula)	L	x	x	X(N) 09.46886° Y(W) 005.57141°
<i>Piliostigma thonningii</i>	<i>Caesalpiniaceae</i>	CNF:21955	Tchiam (senoufo)	L	x		X(N) 09.51678° Y(W) 005.80583°
<i>Bersama abyssinica</i>	<i>Melanthaceae</i>	CNF:1451	-	L, R	x		X(N) 06.16851° Y(W) 005.68340°
<i>Cassia sieberiana</i>	<i>Caesalpiniaceae</i>	CNF:930	Nawolom (senoufo) Sidjan (dioula)	L, R	x		X(N) 09.53232° Y(W) 005.70204°
<i>Cordia myxa</i>	<i>Boraginaceae</i>	IBAAN: 7570	-	L, R	x		X(N) 09.54826° Y(W) 005.70105°
<i>Cissus populnea</i>	<i>Vitaceae</i>	CNF:5377	Bolzangue (senoufo)	W	x		-
<i>Entada abyssinica</i>	<i>Fabaceae</i>	CNF:1433	Yiriwagui (senoufo)	L	x	x	X(N) 09.54765° Y(W) 005.70009°
<i>Euphorbia hirta</i>	<i>Euphorbiaceae</i>	CNF:96	Akololo (baoulé)	W	X		-
<i>Ficus gnaphalocarpa</i>	<i>Moraceae</i>	CNF:5111	Toro (dioula)	L		x	X(N) 09.27597° Y(W) 005.58946°
<i>Griffonia simplicifolia</i>	<i>Fabaceae</i>	CNF:16848	-	L	x		X(N) 06.10275° Y(W) 005.68767°
<i>Guiera senegalensis</i>	<i>Combretaceae</i>	CNF:8607	Koungbè (dioula)	L, R	x		X(N) 09.53537° Y(W) 005.70394°
<i>Khaya senegalensis</i>	<i>Meliaceae</i>	CNF:235	Djarafara (dioula)	L, R	x		X(N) 09.53209° Y(W) 005.70149°

Species	Family	Voucher specimens	Vernacular names	Part used	Use in humans	Use in animals	Geographical coordinates
<i>Landolphia heudelotii</i>	Apocynaceae	CNF:3052	Pkafardjigue (senoufo) Pôpô (dioula)	L	x		X(N) 09.53477° Y(W) 005.70148°
<i>Lophira lanceolater</i>	Ochnaceae	CNF:14219	Chôm (senoufo)	L	x		X(N) 09.54775° Y(W) 005.69985°
<i>Nelsonia canescens</i>	Acanthaceae	CNF:2059	Bassolom (senoufo)	L		x	X(N) 09.46886° Y(W) 005.57141
<i>Opilia celtidifolia</i>	Opiliaceae	CNF:1304	Mougou-plèplè (senoufo)	L		x	X(N) 09.54775° Y(W) 005.69985°
<i>Pterocarpus erinaceus</i>	Fabaceae	CNF:684	N'fougnarimme (senoufo)	L	x		X(N) 09.53217° Y(W) 005.70002°
<i>Saba senegalensis</i>	Apocynaceae	CNF:4284	Kôkôta (dioula)	L	x		X(N) 09.51630° Y(W) 005.80549°
<i>Sida acuta</i>	Malvaceae	CNF:477	Noronorogan (malinké) Kélé kolaka (baoulé)	W	x		-
<i>Simirestis unguiculata</i>	Hippocratéaceae	CNF:3596	Nafrowa (senoufo)	L		x	X(N) 09.53477° Y(W) 005.70148°
<i>Swatzia madagascariensis</i>	Fabaceae	CNF:2882	Lokoum (senoufo)	R	x		X(N) 09.54779° Y(W) 005.70032°
<i>Stylosanthes erecta</i>	Fabaceae	CNF:1186	Sogbofan (senoufo)	L	x		X(N) 09.46886° Y(W) 005.57141°
<i>Uapaca togoensis</i>	Euphorbiaceae	CNF:625	-	L	x		X(N) 09.53217° Y(W) 005.70002°

L=Leaves, R=Root, W = whole plant

The most commonly used families were the *Fabaceae*, *Euphorbiaceae* and *Caesalpiniaceae* which can be attributed to their wide distribution and abundance in the local flora in the study area [15].

For the *Fabaceae* family, the main species collected were *Entada abyssinica*, *Swartzia madagascariensis*, *Pterocarpus erinaceus*, *Griffonia simplicifolia* and *stylosanthes erecta*. These plants are already known for their use in traditional medicines. Several studies have confirmed their biological activities and support their use for the treatment of gastrointestinal infections.

*Entada abyssinica* is also used in eastern tropical Africa for the treatment of coughs, rheumatic and abdominal pains, and diarrhoea while the root or leaf decoction is used in the treatment of fever and to prevent miscarriage [16,17]. Pharmacological properties of *E. abyssinica* have been previously investigated, including anti-inflammatory, antimicrobial and antioxidant [18] properties. Several active compounds have been isolated from *E. abyssinica* including a diastereoisomer of the clerodane type diterpene, kolavenol [19], kolavic acid derivatives [19] and flavonoids and phytosterol glycosides [20]. Freiburghaus et al., [20] isolated four compounds (5S,6R,8aR)-5-(carboxymethyl)-3,4,4a,5,6,7,8,8a-octahydro-5,6,8a-trimethylnaphthalenecarboxylic acid, methyl 3,4,5-trihydroxybenzoate, benzene-1,2,3-triol and 2,3-dihydroxypropyltriacontanoate from this plant. These compounds could be useful for the definition of a standardised antimicrobial improved traditional phytomedicine.

*Swartzia madagascariensis* leaves have also been used in northern Nigeria against some infectious diseases as cutaneous wounds, scabies and venereal diseases [21]. Alkaloids, anthracenes, cardiac glycosides, flavonoids, saponins, steroids, tannins and steroids were found in different extract of this plant [22,23]. The presence of phenolic compounds, which are known to have antibacterial properties could explain the use of the plant in the traditional treatment of cutaneous infections, venereal diseases, and dysentery [23]. A flavonoid, Quercetin has also been reported isolated from the stem bark with strong antifeedant activity [24]. Suter et al. [25] have reported molluscicidal properties of the fruit pods of *Swartzia madagascariensis*. These fruits have already been used to control populations of snail hosts of schistosomiasis in natural pools in Tanzania

since 1939. Phyto-chemical investigation of the dried fruits of *S. madagascariensis* revealed presence of triterpenoid saponins, which were shown to be responsible for the high molluscicidal activity of the fruits [26].

*Pterocarpus erinaceus* is traditionally used for tooth and mouth troubles, and severe diarrhoea or dysentery. Its root is also mixed with tobacco and smoked in a pipe as a cough remedy [27]. *Pterocarpus erinaceus* contains tannins, flavonoids, phenols and saponins. It has also been confirmed that its stem bark possesses a broad antimicrobial spectrum including *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans* [27–29]. Tittikpina et al. [29] isolated four compounds from the plant, i.e. friedeline, 2,3-dihydroxypropyloctacosanoate, a mixture of  $\beta$ -sitosterol stigmasterol and campesterol;  $\beta$ -sitosteryl- $\beta$ -D-glucopyranoside which were found to be active against bacteria.

*Griffonia simplicifolia* is a perennial woody shrub, which grows in the tropical rain forest of West and Central Africa. It is traditionally used in the treatment of depression, obesity, insomnia, fibromyalgia, migraine, and it improves cognitive functions [30,31]. It is also used for aphrodisia and antibiotic purposes as well as a remedy for diarrhoea, vomiting and stomach aches [32]. Phytochemical studies indicated the presence of glycosides, tannins, flavonoids, alkaloids, saponins and coumarins in the leaf extract of the plant [33]. In the seed, many authors have also found lectins 5-hydroxy-L-tryptophan (5-HTP) a direct precursor in the synthesis of serotonin (5-HT) and fatty acids [34,35].

Leaves are the most commonly used organs, followed by bark. Authors such as Séguéna et al., Sandhya et al. and Zerbo et al. [36–38] have also shown that leaves are the most commonly used plant organs in traditional medicine for the treatment of various diseases. The abundance of chemical groups in the leaves may explain their frequent use in traditional medicines. Leaves are the location for most of the synthesis of secondary metabolites [39].

According to Sanogo et al., *Stylosanthes erecta* P. Beauv (Fabaceae) extracts demonstrated an antibacterial activity against clinical strains of *Escherichia coli* [40] and showed a binding ability to the GABAA–benzodiazepine receptor complex [41]. These results can justify the use of *Stylosanthes erecta* in traditional medicine.

The chemicals found in some plants may explain their use. For example, *Alchornea cordifolia* and *Anogeissus leiocarpa* contain tannins [42,43] well-known for their anti-diarrheal properties and astringent action [43,44]. *Bauhinia thonningii* (*Ptilostigma thonningii*) has shown antibacterial activity against *Bacillus subtilis*, *Corynebacterium pyogenes*, *Escherichia coli*, *Proteus vulgaris*, *Shigella dysenteriae* and *Staphylococcus aureus* and larvicidal activity *in vitro* against intestinal parasites of cattle [45,46]. The methanol stem-bark extract of *Annona senegalensis* was investigated using both *in vivo* and *in vitro* models. Oral administration of 5000mg/kg of extract to mice previously fed with charcoal meal was used to investigate intestinal transit time. The extract decreased intestinal transit time by decreasing the spontaneous contractions of the intestine. This activity supports thus the use of *Annona senegalensis* stem bark extract in the treatment of diarrhoea [44].

According to this study, all the organs of the plants are mainly prepared as decoctions. This water extraction process can collect most active ingredients and reduces or eliminates the toxic effect of some other preparations [47]. These preparations used to be used for local application or for oral administration (drinks and rectal purges) [48].

#### 4. CONCLUSION

The ethnobotanical study is an essential step in the identification of plants of interest to start analytical experiments. This work assessed the diversity of medicinal plants and plant organs used in the traditional treatment of diarrhoea. The diversity of plants used during diarrhoea can be related to the medicinal species use knowledge, the diversity of plant origin, and the experience of traditional healers. Some of the plants listed during this study are region-specific, while other can be found all over Ivory Coast.

Among the organs used, the leaves predominate, mostly prepared as decoction for oral administration. Bioassays are planned to investigate the therapeutic properties of the plants, especially against cryptosporidiosis.

#### CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

#### ETHICAL APPROVAL

This study was organized under the Nagoya protocol statement.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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