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An ethnobotanical survey of traditional medicinal plants used against tuberculosis and symptoms associated in Abidjan, Côte d'Ivoire

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[2]Laboratory of Biology and Health, Faculty of Biosciences, University of Felix Houphouet-Boigny. 01 PO. Box V 34, Abidjan 01, Republic of Côte d'Ivoire

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Abstract. *Kande B, Grah ZM, Moyabi AGA, Soro Y, Kone WM. 2023. An ethnobotanical survey of traditional medicinal plants used against tuberculosis and symptoms associated in Abidjan (Côte d'Ivoire). Asian J Ethnobiol 6: 36-45.* Infectious diseases, including tuberculosis, are responsible for one-third of the world's mortality due to the mechanism of resistance to antibiotics. Faced with this alarming situation, the search for active principles from natural substances is a primordial need. In this study, semi-structured questionnaires conducted an ethnobotanical survey of medicinal plants used against tuberculosis and associated symptoms in Abidjan. Information was gathered from 171 herbalists. The respondents were asked questions regarding their use of medicinal plants to treat tuberculosis and associated symptoms. Information entailing plants used to treat tuberculosis, associated symptoms, plant parts used, mode of preparation, and dosage was recorded. The results showed that it is known among traditional medicine practitioners to cure tuberculosis but is better understood by its associated symptoms. These surveys revealed a diversity of 41 species of medicinal plants against this disease and its associated symptoms. They are mostly trees. *Alchornea cordifolia* (Schumach. & Thonn.) Müll.Arg. (Euphorbiaceae), *Bombax costatum* Pellegr. & Vuillet (Bombacaceae), *Ficus sur* Forssk. (Moraceae), *Kigelia africana* (Lam.) Benth. (Bignoniaceae), *Nephrolepis bisserata* (Sw.) Schott (Nephrolepidaceae), *Terminalia glaucescens* Planch. ex Benth. (Combretaceae) and *Vitellaria paradoxa* C.F.Gaertn. (Sapotaceae) are the most cited plant species. Leaves are the most used organs, decoction is the main mode of preparation, and the oral route is the main way to administer the remedies.

Keywords: Côte d'Ivoire, ethnobotanical survey, herbalists, medicinal plants, tuberculosis

INTRODUCTION

Humans are often confronted with two types of diseases. These are transmittable diseases and not transmittable diseases. Non-transmissible diseases are non-infectious diseases that cannot be transmitted between people. Transmissible diseases are carried by a pathogen, which releases toxins and deploys its genetic material in the human body, thus affecting the immune system. This is the case of bacterial germs responsible for infectious diseases (Van-Hoek et al. 2011). Respiratory infections are many; among them, Tuberculosis (TB) is responsible for one-third of global mortality (WHO 2017).

Tuberculosis is a transmissible infectious disease that causes the largest number of deaths worldwide and is one of the most important causes of mortality resulting from antimicrobial resistance (Alexander et al. 2010). *Mycobacterium tuberculosis* causes this disease (Agus et al. 2022), responsible for 98-99% of pulmonary TB and 80-90% of all TB diseases. In addition, TB is one of the top 10 causes of death worldwide and the leading cause of death from a single infectious agent, ranking ahead of HIV/AIDS (WHO 2016a,b).

Treating bacterial infections has become more complicated due to drug-resistant strains. In addition, many developing countries, particularly in rural areas, have less developed, less equipped, or even non-existent health structures. In addition, the duration of the treatment becomes very restrictive for the patient. Due to the limited success of current drugs, there is an urgent need to identify new treatments for this disease. Statistics from the World Health Organization (WHO 2002), still in effect according to Mangambu et al. (2014), show that more than 80% of the African and even Ivorian populations resort to traditional medicine for their health problems. This recourse to traditional medicine is conducted as a first resort for proximity, availability, and accessibility to plant resources (Adjet et al. 2017). It is done as a last resort when the therapy administered at the hospital does not show signs of healing more quickly (Ayéna 2012). Then, populations complement the care they receive in hospitals with treatment with medicinal plants (Kolling et al. 2010).

Medicinal plants are a good source of drugs, and the search for new drugs from plants is now a well-justified issue (Balunas and Kinghorn 2005). In addition, bacterial antibiotic resistance has become a real concern (Akoua et al. 2004). This general antibiotic resistance phenomenon

concerns all bacterial species and constantly increases. This study aims to gather information from herbalists on traditional medicinal plants that treat tuberculosis and associated symptoms in Abidjan (Côte d'Ivoire).

MATERIALS AND METHODS

Study area

Ethnobotanical surveys were conducted in three large communes based on population density, Abobo (1,340,083 inhabitants), Port-Bouët (618,795 inhabitants), and Yopougon (1,571,065 inhabitants) in the autonomous district of Abidjan. The district of Abidjan (Côte d'Ivoire) where this study took place is located between 5°20'27" N and 4°01'41" W (Figure 1). The population of these communes is very diversified, cosmopolitan, and composed of several peoples and ethnic groups from various regions of the country but also from neighboring countries (INS 2021).

Herbalist survey

Data were collected between April and September 2019. They consisted of semi-structured interviews based on a questionnaire. The recorded information included the age group and gender of the persons interviewed, the plants used in the different recipes, parts of the plants used, the mode of preparation, forms of administration of the medicinal plants, and posology. Plants were collected with the assistance of herbalists. Voucher specimens were prepared, and botanists identified plant species at the University Nangui Abrogoua. The authentification was compared with the voucher specimens of the National Center of Floristics (University Felix Houphouët Boigny). The APG IV (2016) nomenclature system was adopted for the names of taxa.

Data analysis of botanical and ethnobotanical characteristics of the identified plants

The plants used to treat tuberculosis, and associated symptoms were characterized by their biological, morphological, and biogeographical types. The data analysis focused on determining each species, the Relative Frequency of Citation (RFC), plant contribution in the Constitution of the Recipes (CPr), and the specificity of the recipes concerning the symptoms.

Relative frequency of citation of plant species in the treatment of tuberculosis and associated symptoms

To determine the most cited plant species for treating tuberculosis and associated symptoms, we used the Relative Frequency of Citation (RFC). It is used to evaluate the importance of the plants and the credibility of the information received. It was determined for each species by formula 1 (Dassou et al. 2015):

$$RFC = NP/NT \times 100 \quad (1)$$

Where:
NP: Number of times the plant was used
NT: Total number of herbalists

Contribution of each plant species in the recipes in the treatment of tuberculosis and associated symptoms

The CPr measures the frequency of a plant's involvement in the recipes. It was determined for each species by formula 2 (Dassou et al. 2015):

$$CPr = Nr \times 100/Nt \quad (2)$$

Where:
Nr: Number of recipes involving the plant
Nt: Total number of recipes

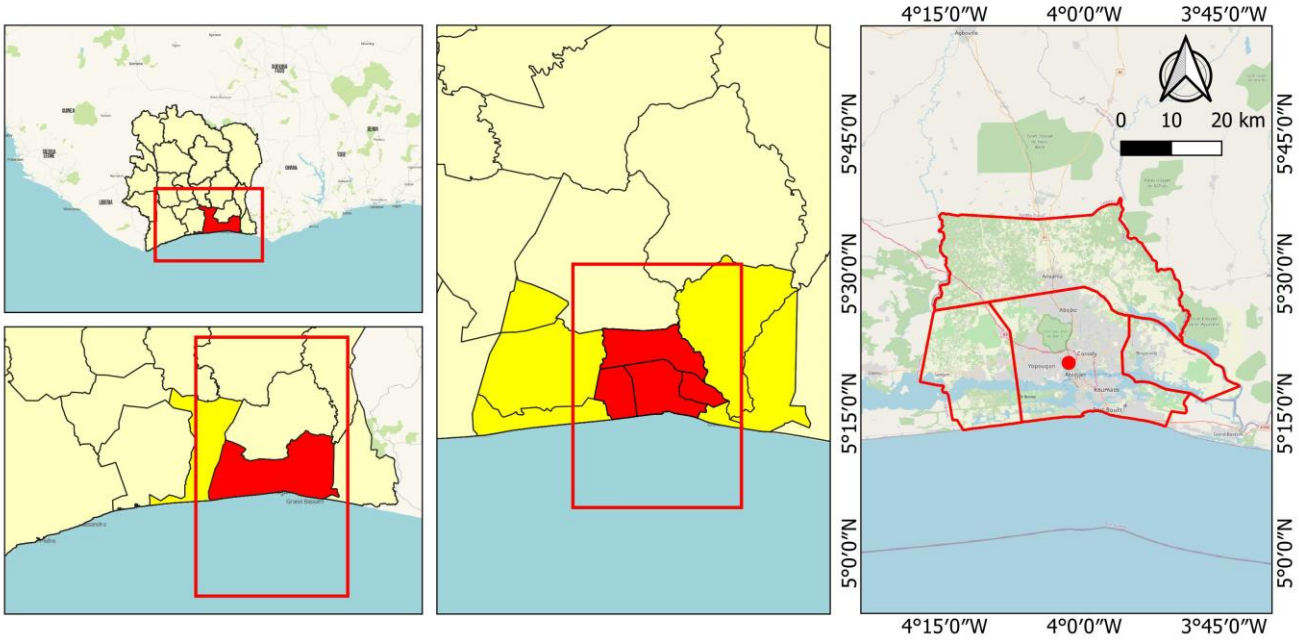

Figure 1. Location of the study area in Côte d'Ivoire

Specificity of the recipes concerning symptoms associated with tuberculosis

Therefore, to estimate the specificity of each plant recipe concerning TB-associated symptoms, its Frequency (Fr) of citation was calculated by the following formula 3:

$$FR = n/(N) \times 100 \quad (3)$$

Where:

n: Number of times a recipe treats the symptom

N: Number of citations of symptoms associated with tuberculosis.

Informant Consensus Factor (ICF) has been used to assess the degree of consistency of information in therapy data (Heinrich et al. 1998). In addition, it is used to assess informants' agreement on the reported therapies for each type of use (Formula 4).

$$ICF = (Nur - Nt)/(Nu - 1) \quad (4)$$

Where:

Nur: Number of use citations in each symptom was mentioned

Nt: Number of species plant(s) used for this symptom

The ICF ranges from 0 (plants are randomly selected, or informants have different views on the treatment for a given disease and do not exchange information on their use) to 1 (there is a well-defined selection criterion in the community and/or if the information is exchanged between informant (Heinrich et al. 1998).

Data analysis

Survey data were entered using Epidata 3.1 software and then transferred to SPSS 20.0 software for analysis. The tables were carried out with SPSS 20.0 and Excel software to establish a relationship to appreciate better and explain the socio-demographic characteristics of the respondents, the floristic diversity of plants used to treat pulmonary tuberculosis and associated symptoms, and the therapeutic modalities.

RESULTS AND DISCUSSION

Socio-demographic characteristics of the herbalists surveyed (Autonomous District of Abidjan)

A total of 171 herbalists were interviewed on the therapeutic use of medicinal plants in the Autonomous District of Abidjan to treat TB-related symptoms. The majority of herbalists interviewed were women (92.40%). Based on the age range proposed by Assogbadjo et al. (2008), three age groups were obtained (Table 1), young people under 29 years of age (22.22%), adults between 30 and 59 years of age (73.68%), and older people over 60 years of age (4.09%). Two levels of schooling are more represented than others, i.e., illiterate (52.05%) and primary school (30.99%).

Herbalists' knowledge of tuberculosis and associated symptoms

In the markets, all herbalists interviewed know tuberculosis. For example, the local names for TB most commonly used in the markets were *socôsocôgbê* (53.80%) in Malinké and *tangôhoufoué* (42.11%) in Baoulé. Herbalists mentioned several causes of tuberculosis, the highest being caused by microbes (81.87%). Others, such as witchcraft, heredity, housing, and diet, account for 18.13%.

Diversity of plant species and importance of plants used in the treatment of tuberculosis and associated symptoms

The survey identified 41 plant species belonging to 26 families and 39 genera. These medicinal species are mainly represented by dicots (97.56%) and a single monocot, *C. citratus* (Poaceae). The most represented families are Fabaceae (14.63%), Annonaceae (7.32%), and Euphorbiaceae (7.32%) (Table 2).

Morphological types of the antituberculosis and its associated symptoms plants according to the herbalists' survey

The plant species marketed to treat tuberculosis and its associated symptoms are, for the most part, shrubs (43.90%), followed by trees (29.27%), herbaceous plants (19.51%), and lianas (7.32%). Seven biological types mostly belong to microphanerophytes (41.46%) and mesophanerophytes (24.39%) (Figure 2).

Biogeographic types of antituberculosis and its associated symptoms plants according to the herbalists' survey

At the level of phytogeographical affinities, the species of the transition zone of the Sudano-Zambezian regions (SZ) are the most numerous (41.46%). They are followed by species from the Guinean-Congolese (GC) regions with a percentage of 19.51 and Sudano-Guinean (SG) with 17.07%. On the other hand, introduced species (Int), Sudano-Zambezian (SZ), Sudanian (S), and Pantropical (Pt) are the least represented with 7.32%, 7.32%, 4.88%, and 2.44%, respectively.

Table 1. Demographic profile of the herbalists surveyed in Autonomous District of Abidjan, Côte d'Ivoire

Parameters	Proportions (%)
Gender	
Women	92.4
Men	7.6
Total	100
Age group	
Youth [23 to 29]	22.22
Adults [30 to 59]	73.68
Elders ≥ 60	4.09
Total	100
Education degree	
Not enrolled in school	30.99
Primary school	52.05
Secondary school	5.26
Islamic school	11.70
Total	100

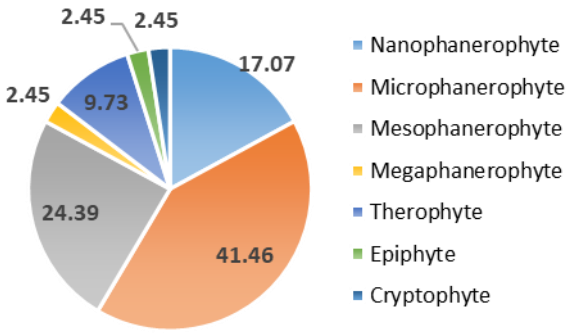

Figure 2. The spectrum of biological types of plant species used in the treatment of tuberculosis and associated symptoms

Ethnobotanical characteristics of the antituberculosis and its associated symptoms plants according to the herbalists' survey

Of the various plant parts inventoried, the leaves (44.63%) are the most used, followed by the bark (28.93%) and the roots (25.62%), and Fruits (0.83%) are used very less in the treatment of this disease and its associated symptoms. The plants identified are used in 63 medicinal recipes to treat tuberculosis and its associated symptoms (Table 3). The relative frequencies of citation of the inventoried species vary from 0.58% to 25.14%. The species most cited by herbalists are, in descending order of their relative frequency of citation (RFC), *A. cordifolia* (25.14%), *H. rotundifolia* (15.20%), and *Z. zanthoxyloides* (8.77%). Among the commercialized species, two are present on the International Union for Conservation of Nature (IUCN) list, i.e., *K. senegalensis* and *V. paradoxa* are vulnerable species.

Table 2. Botanical and ethnobotanical characteristics of plant species used in the treatment of tuberculosis and associated symptoms

Species	Family	CF (%)	Biolo. type	Morpho. type	Chorol. type
Abrus precatorius L.	Fabaceae	0.58	mph	Liana	GC-SZ
Ageratum conyzoides L.	Asteraceae	1.17	Th	Herbaceous	GC-SZ
Alchornea cordifolia (Schumach. & Thonn.)	Euphorbiaceae	25.15	mph	Shrub	GC-SZ
Annona muricata L.	Annonaceae	1.75	nph	Shrub	Int
Annona senegalensis Pers.	Annonaceae	0.58	nph	Shrub	SZ
Bidens pilosa L.	Asteraceae	2.34	Th	Herbaceous	GC-SZ
Bombax costatum Pellegr. & Vuillet.	Bombacaceae	0.58	mph	Shrub	SZ
Bridelia ferruginea Benth.	Euphorbiaceae	1.17	mph	Shrub	GC-SZ
Cassia nilotica (L.) Willd.	Fabaceae	0.58	mPh	Tree	SZ
Cassia occidendalis L.	Fabaceae	0.58	nph	Shrub	GC-SZ
Ceiba pentandra (L.) Gaertn.	Bombacaceae	1.75	MPh	Tree	GC-SZ
Citrus aurantifolia (Christm.) Swingle	Rutaceae	2.34	mph	Shrub	Int
Cleistopholis patens (Benth.) Engl. & Diels.	Annonaceae	0.58	mPh	Tree	GC
Crossopteryx febrifuga (Afzel.) Benth.	Rubiaceae	1.75	mph	Shrub	GC-SZ
Cymbopogon citratus (DC.) Stapf.	Poaceae	0.58	Hc	Herbaceous	GC-SZ
Desmodium adscendens (Swartz) D.C.	Fabaceae	2.34	nph	Shrub	GC
Eucalyptus camaldulensis Dehnhardt.	Myrtaceae	0.58	mPh	Tree	Int
Ficus sur Forssk.	Moraceae	2.34	mph	Shrub	GC
Harungana madagascariensis Auct.	Hypericaceae	0.58	mph	Shrub	GC
Heliotropium indicum L.	Boraginaceae	0.58	Th	Herbaceous	SG
Heterotis rotundifolia (Sm.) Jacq. - Fél	Melastomataceae	15.20	Th	Herbaceous	At
Khaya senegalensis (Desr.) A Juss	Meliaceae	3.51	mph	Tree	GC
Kigelia africana (Lam.) Benth.	Bignoniaceae	0.58	mPh	Tree	SG
Morinda lucida Benth.	Rubiaceae	2.34	mph	Shrub	GC-SZ
Nephrolepis bisserata (Sw.) Schott.	Nephrolepidaceae	1.17	Ep	Liana	GC-SZ
Newbouldia laevis (P. Beauv.) Seeman	Bignoniaceae	0.58	mph	Shrub	SG
Ocimum gratissimum L.	Lamiaceae	2.9	nph	Herbaceous	GC-SZ
Palisota hirsuta (Thunb.) K. Schum.	Commelinaceae	0.58	nph	Herbaceous	GC
Parkia biglobosa (Jacq.) R. Br.	Mimosaceae	1.75	mPh	Tree	S
Paullinia pinnata L.	Sapindaceae	0.58	mph	Liana	GC-SZ
Piliostigma thonningii (Schum.) Milne-Red.	Fabaceae	1.17	mph	Shrub	GC-SZ
Pterocarpus erinaceus Poir.	Fabaceae	0.58	mPh	Tree	S
Rauvolfia vomitoria Afzel.	Apocynaceae	0.58	mph	Shrub	GC-SZ
Ricinodendron heudelotii (Baill.) Pierre.	Euphorbiaceae	1.17	mPh	Tree	GC
Scoparia dulcis L.	Plantaginaceae	1.75	nph	Herbaceous	Pt
Spondias mombin L.	Anacardiaceae	3.51	mph	Shrub	GC-SZ
Terminalia brownii Fresen.	Combretaceae	1.75	mPh	Tree	SG
Terminalia glaucescens (Planch.)	Combretaceae	1.17	mPh	Tree	SG
Trema orientalis (L.) Blume	Ulmaceae	1.75	mph	Shrub	GC-SZ
Vitellaria paradoxa C.F.Gaertn.	Sapotaceae	0.58	mPh	Tree	SG
Zanthoxylum zanthoxylloides (Lam.)	Rutaceae	8.77	mph	Shrub	SG

Note: Morph. type : morphological type; Chorol. type: chorological type; GC: taxon from the Guineo-Congolese region; SZ: taxon from the Sudan-Zambezi region; GC-SZ: taxon from the transition region and the Guineo-Congolese and Sudan-Zambezi regions; i: introduced and cultivated taxon; Biolo. type: biological type; nph: nanophanerophyte species; mph: microphanerophyte species; mPh: mesophanerophyte species; MPh: megaphanerophytes species; Th: therophyte species; Ep: epiphyte; Cr: cryptophyte; CF: citation frequency

Table 3. List of recipes of plant species used in the treatment of tuberculosis and associated symptoms delivered by the herbalists surveyed

Types of recipes		Plant species and Parts used	Posology
Bispecific recipes (2 species)	R1	*Nephrolepsis bisserata* (leaves); *Bombax costatum* (stems bark)	2 cups (35cl) / morning and evening
	R2	*Cleistopholis patens* (stems bark); *Morinda lucida* (roots)	1 cup (35cl) / morning and evening
Multispecies recipes (3 species)	R3	*Vitellaria paradoxa* (stems); *Terminalia glaucescent* (stems)	2 cups (35cl) / morning and evening
	R4	*Zanthoxylum zanthoxylloides* (roots); *Annona muricata* (leaves); *Abrus precatorius* (stems bark)	2 cups (35cl) / morning and evening
	R5	*Cassia occidentalis* (leaves); *Heterotis rotundifolia* (whole plant); *Ficus sur* (stems bark)	2 cups (35cl) / morning and evening
	R6	*Khaya senegalensis* (stems bark); *Scoparia dulcis* (leaves); *Paullinia pinnata* (roots)	1 cup (50cl) / morning and evening
	R7	*Alchornea cordifolia* (roots); *Terminalia brownii* (roots); *Palisota hirsuta* (leaves)	2 cups (35cl) / morning and evening
Multispecies recipes (3 species)	R8	*Bidens pilosa* (leaves); *Bombax costatum* (stems bark); *Piliostigma thonningii* (leaves)	1 cup (35cl) / morning, noon, and evening
	R9	*Alchornea cordifolia* (roots); *Vitellaria paradoxa* (stems bark); *Terminalia glaucescent* (stems bark)	2 cups (35cl) / morning and evening
	R10	*Alchornea cordifolia* (leaves); *Rauvolfia vomitoria* (roots); *Ricinodendron heudelotii* (stems bark)	2 cups (35cl) / morning and evening
	R11	*Alchornea cordifolia* (roots); *Pterocarpus erinaceus* (stems bark); *Nephrolepsis bisserata* (leaves)	2 cups (35cl) / morning and evening
	R12	*Zanthoxylum zanthoxylloides* (roots); *Paullinia pinnata* (roots); *Bridelia ferruginea* (stems bark)	1 cup (35cl) / morning and evening
	R13	*Zanthoxylum zanthoxylloides* (roots); *Palisota hirsuta* (leaves); *Ageratum conyzoides* (leaves)	2 cups (35cl) / morning and evening
	R14	*Zanthoxylum zanthoxylloides* (roots); *Kigelia africana* (stems bark); *Trema orientalis* (leaves)	2 cups (35cl) / morning and evening
Multispecies recipes (3 species)	R15	*Heterotis rotundifolia* (whole plant); *Heliotropium indicum* (whole plant); *Terminalia brownii* (root)	2 cups (35cl) / morning and evening
	R16	*Heterotis rotundifolia* (whole plant); *Harungana madagascariencis* (stems bark); *Parkia biglobosa* (root)	2 cups (35cl) / morning and evening
	R17	*Heterotis rotundifolia* (whole plant); *Eucalyptus camaldulencis* (leaves); *Crossopteryx febrifuga* (stems bark)	2 cups (35cl) / morning and evening
	R18	*Ocimum gratissimum* (leaves); *Cymbopogon citratus* (leaves); *Ceiba pentandra* (stems bark)	2 cups (35cl) / morning and evening
	R19	*Khaya senegalensis* (stems bark); *Cleistopholis patens* (stems bark); *Annona muricata* (leaves)	2 cups (35cl) / morning and evening
	R20	*Morinda lucida* (root); *Ricinodendron heudelotii* (root); *Cassia occidentalis* (leaves)	2 cups (35cl) / morning and evening
	R21	*Spondias mombin* (leaves); *Heterotis rotundifolia* (whole plant); *Ageratum conyzoides*(whole plant)	2 cups (35cl) / morning and evening

Multispecies recipes (3 species)	R22	*Desmodium adscendens* (whole plant); *Annona senegalensis* (leaves); *Piliostigma thonningii* (leaves)	1 cup (50cl) / morning and evening
	R23	*Citrus aurantifolia* (root); *Parkia biglobosa* (root); *Newbouldia laevis* (leaves)	1 cup (35cl) / morning, noon, and evening
	R24	*Ficus sur* (stems bark); *Trema orientalis* (leaves); *Pterocarpus erinaceus* (stems bark)	1 cup (35cl) / morning, noon, and evening
	R25	*Annona muricata* (leaves); *Scoparia dulcis* (whole plant); *Desmodium adscendens* (whole plant)	1 cup (50cl) / morning, noon, and evening
	R26	*Ceiba pentandra* (stems bark); *Morinda lucida* (root); *Heliotropium indicum* (whole plant)	2 cups (35cl) / morning and evening
	R27	*Crossopteryx febrifuga* (leaves); *Bidens pilosa* (leaves); *Rauvolfia vomitoria* (root)	2 cups (35cl) / morning and evening
	R28	*Parkia biglobosa* (root); *Khaya senegalensis* (stems bark); *Eucalyptus camaldulensis* (leaves)	2 cups (35cl) / morning and evening
Multispecies recipes (3 species)	R29	*Scoparia dulcis* (whole plant); *Palisota hirsuta* (leaves); *Heterotis rotundifolia* (whole plant)	2 cups (35cl) / morning and evening
	R30	*Terminalia brownie* (root); *Alchornea cordifolia* (root); *Annona senegalensis* (leaves)	2 cups (35cl) / morning and evening
	R31	*Trema orientalis* (leaves); *Zanthoxylum zanthoxylloides* (root); *Cleistopholis patens* (stems bark)	2 cups (35cl) / morning and evening
	R32	*Ageratum conyzoides* (whole plant); *Ocimum gratissimum* (leaves); *Kigelia africana* (stems bark)	2 cups (35cl) / morning and evening
	R33	*Bridelia ferruginea* (stems bark); *Desmodium adscendens* (whole plant); *Cassia nilotica* (fruits)	2 cups (35cl) / morning and evening
	R34	*Piliostigma thonningii* (leaves); *Morinda lucida* (root); *Cassia occidentalis* (leaves)	2 cups (35cl) / morning and evening
	R35	*Ricinodendron heudelotii* (roots); *Khaya senegalensis* (stems bark); *Abrus precatorius* (leaves)	2 cups (35cl) / morning, noon, and evening
Multispecies recipes (3 species)	R36	*Terminalia glaucescent* (stems bark); *Spondias mombin* (leaves); *Paullinia pinnata* (roots)	2 cups (35cl) / morning and evening
	R37	*Abrus precatorius* (leaves); *Alchornea cordifolia* (roots); *Annona muricata* (leaves)	1 cup (50cl) / morning and evening
	R38	*Annona senegalensis* (leaves); *Zanthoxylum zanthoxylloides* (roots); *Ceiba pentandra* (stems bark)	1 cup (50cl) / morning and evening
	R39	*Bombax costatum* (stems bark); *Heterotis rotundifolia* (whole plant); *Crossopteryx febrifuga* (leaves)	2 cups (50cl) / morning and evening
	R40	*Cassia nilotica* (fruits); *Ocimum gratissimum* (leaves); *Parkia biglobosa* (roots)	2 cups (50cl) / morning and evening
	R41	*Cassia occidentalis* (leaves); *Khaya senegalensis* (stems bark); *Scoparia dulcis* (whole plant)	2 cups (35cl) / morning and evening
	R42	*Cymbopogon citratus* (leaves); *Spondias mombin* (leaves); *Ageratum conyzoides* (whole plant)	2 cups (35cl) / morning and evening
Multispecies recipes (3 species)	R43	*Eucalyptus camaldulensis* (leaves); *Bidens pilosa* (leaves); *Terminalia brownii* (roots)	2 cups (35cl) / morning and evening
	R44	*Harungana madagascariensis* (stems bark); *Citrus aurantifolia* (roots); *Trema orientalis* (leaves)	2 cups (35cl) / morning and evening

	R45	*Heliotropium indicum* (leaves); *Bridelia ferruginea* (stems bark); *Desmodium adscendens* (leaves)	2 cups (35cl) / morning and evening
	R46	*Kigelia africana* (stems bark); *Ficus sur* (stems bark); *Nephrolepsis bisserata* (leaves)	2 cups (35cl) / morning and evening
	R47	*Newbouldia laevis* (leaves); *Bidens pilosa* (leaves); *Heterotis rotundifolia* (leaves)	2 cups (35cl) / morning and evening
	R48	*Palisota hirsuta* (leaves); *Ocimum gratissimum* (leaves); *Ageratum conyzoides* (whole plant)	2 cups (35cl) / morning and evening
	R49	*Paullinia pinnata* (roots); *Khaya senegalensis* (stems bark); *Parkia biglobosa* (roots)	2 cups (35cl) / morning and evening
Multispecies recipes (3 species)	R50	*Pterocarpus erinaceus* (stems bark); *Desmodium adscendens* (whole plant); *Annona muricata* (leaves)	2 cups (35 cl) / morning and evening
	R51	*Rauvolfia vomitoria* (roots); *Alchornea cordifolia* (roots); *Ocimum gratissimum* (leaves)	1 cup (50 cl) / morning and evening
	R52	*Pterocarpus erinaceus* (stems bark); *Alchornea cordifolia* (roots); *Terminalia brownii* (roots)	2 cups (35 cl) / morning and evening
	R53	*Harungana madagascariensis* (stems bark); *Trema orientalis* (leaves); *Bridelia ferruginea* (stems bark)	2 cups (35 cl) / morning, noon, and evening
	R54	*Palisota hirsuta* (leaves); *Ocimum gratissimum* (leaves); *Alchornea cordifolia* (roots)	2 cups (35 cl) / morning, noon, and evening
Multispecies recipes (4 species)	R55	*Alchornea cordifolia* (roots); *Ageratum conyzoides* (whole plant); *Ocimum gratissimum* (leaves); *Cassia occidentalis* (leaves)	2 cups (35 cl) / morning, noon, and evening
	R56	*Ocimum gratissimum* (leaves); *Ceiba pentandra* (stems bark); *Bombax costatum* (stems bark); *Bidens pilosa* (leaves)	2 cups (50 cl) / morning and evening
	R57	*Morinda lucida* (roots); *Citrus aurantifolia* (roots); *Bridelia ferruginea* (stems bark); *Cassia nilotica* (fruits)	1 cup (50 cl) / morning, noon, and evening
	R58	*Bidens pilosa* (leaves); *Abrus precatorius* (leaves); *Ficus sur* (stems bark); *Citrus aurantifolia* (roots)	2 cups (35cl) / morning and evening
	R59	*Bidens pilosa* (leaves); *Morinda lucida* (roots); *Khaya senegalensis* (stems bark); *Zanthoxylum zanthoxylloides* (roots)	2 cups (35cl) / morning and evening
	R60	*Rauvolfia vomitoria* (roots); *Alchornea cordifolia* (roots); *Ageratum conyzoides* (leaves); *Newbouldia laevis* (leaves)	2 cups (35cl) / morning and evening
Multispecies recipes (5 species)	R61	*Scoparia dulcis* (whole plant); *Palisota hirsuta* (leaves); *Terminalia brownii* (roots); *Ceiba pentandra* (stems bark); *Piliostigma thonningii* (leaves)	2 cups (35cl) / morning and evening
	R62	*Heliotropium indicum* (whole plant); *Bridelia ferruginea* (stems bark); *Desmodium adscendens* (leaves); *Khaya senegalensis* (stems bark); *Kigelia africana* (stems bark)	1 cup (50 cl) / morning and evening
	R63	*Kigelia africana* (stems bark); *Ficus sur* (stems bark); *Nephrolepsis bisserata* (leaves); *Vitellaria paradoxa* (stems bark); *Terminalia glaucescent* (stems bark)	2 cups (35 cl) / morning and evening

Notes**:** The method of preparation and administration are decoction and taken orally; cl: centiliter; R: recipes

The plant species most used by herbalists in the different recipes, in decreasing order of frequency of contribution (CPr), are *A. cordifolia* (CPr = 17.46%), *H. rotundifolia* (CPr = 12.69%), *K. senegalensis* (CPr = 12.69%), *O. gratissimum* (CPr = 12.69%), *A. conyzoides* (CPr = 11.11%), and *B. pilosa* (CPr = 11.11%) (Table 4).

Agreement on the therapy and use of medicinal plants against the symptoms associated with tuberculosis

The agreement on the treatment of the symptoms associated with tuberculosis showed that the associated symptoms have a high consensus. These are chronic cough (0.84), fever (0.82), asthenia (0.80), bloody cough (0.80), muscle pain (0.78), pain thoracic (0.73), and chronic weight loss (0.60). The most cited species in the treatment of these symptoms are *A. cordifolia*, *T. brownii*, *P. hirsuta*, *K. senegalensis*, *S. dulcis*, *P. pinnata*, *C. occidentalis*, *H. rotundifolia*, *F. sur*, *Z. zanthoxylloides*, *A. muricata*, *A. precatorius*, *V. paradoxa*, *T. glaucescent*, and *C. patens* (Table 5).

Discussion

The present study collected information on the plants marketed in the autonomous district of Abidjan and used to treat tuberculosis and associated symptoms. In the markets of the communes of Abobo, Yopougon, and Port-Bouët, this study was conducted among 171 herbalists, the majority of whom were women (92.40%). The predominance of women among herbalists has already been reported by similar studies conducted in Côte d'Ivoire by Ambé et al. (2015) in the markets of Abidjan with 96.00% women. This same finding was made by Hermans et al. (2004) in the markets of southern Benin, where 100% of herbalists are women. This can be explained by the fact that in Côte d'Ivoire, selling in markets is an activity usually undertaken by women. In contrast, in the markets of Dakar, Senegal (Dasylva 2001), Burkina Faso (Sanon et al. 2003), and Mali (Togola et al. 2005), men are the most numerous in the medicinal plant trading. This could be due to environmental and socio-cultural differences between these regions and the Abidjan district.

Regarding age, herbalists over 30 years old are the most numerous because they have more knowledge of the uses of medicinal plants, and their properties are usually acquired as a result of long-accumulated experience. In addition, plant virtues are ancestral knowledge transmitted from generation to generation (Benlamdini et al. 2014). This study shows that 52.02% of those surveyed have a minimum level of primary education. This demonstrates the professionalism of these herbalists, which is gradually gaining ground. This education could promote the adoption of good practices in storing and delivering commercialized medicinal plants. On the other hand, previous studies conducted in other regions of Côte d'Ivoire by Gnagne et al. (2017), Sidio et al. (2020), and Koman et al. (2021) show that this activity is practiced mostly by uneducated people.

The ethnobotanical survey led to 41 plant species marketed to treat tuberculosis and its associated symptoms. These inventoried plant species reflect their diversity in treating these pulmonary diseases and denote the richness of knowledge acquired in the field. Among the species identified in this study, the Fabaceae (14.63%) is the most numerous. That can be explained by the new nomenclature adopted by APG IV (2016), which combines, within this family, the Mimosaceae and Ceasalpiniaceae.

Table 4. Some ethnobotanical parameters of plants used against tuberculosis and associated symptoms in the District of Abidjan, Côte d'Ivoire

Species	[1]RFC (%)	[2]CPr (%)
Alchornea cordifolia (Schumach. & Thonn.)	25.14	17.46
Heterotis rotundifolia (Sm.) Jacq. - Fél	15.2	12.69
Zanthoxylum zanthoxyloides (Lam.)	8.77	11.11
Khaya senegalensis (Desr.) A Juss	3.5	12.69
Spondias mombin L.	3.5	4.76
Ocimum gratissimum L.	2.92	12.69
Bidens pilosa L.	2.33	11.11
Citrus aurantifolia (Christm.) Swingle	2.33	6.349
Desmodium adscendens (Swartz) D.C.	2.33	9.52
Ficus sur Forssk.	2.33	7.93
Morinda lucida Benth.	2.33	9.52
Annona muricata L.	1.75	7.93
Ceiba pentandra (L.) Gaertn.	1.75	7.93
Crossopteryx febrifuga (Afzel.) Benth.	1.75	4.76
Parkia biglobosa (Jacq.) R. Br.	1.75	7.93
Scoparia dulcis L.	1.75	7.93
Terminalia brownii Fresen.	1.75	9.52
Trema orientalis (L.) Blume	1.75	7.93
Ageratum conyzoides L.	1.16	11.11
Bridelia ferruginea Benth.	1.16	9.52
Nephrolepis bisserata (Sw.) Schott.	1.16	6.34
Piliostigma thonningii (Schum.) Milne-Red.	1.16	6.34
Ricinodendron heudelotii (Baill.) Pierre.	1.16	4.76
Terminalia glaucescens (Planch.)	1.16	6.34
Abrus precatorius L.	0.58	6.34
Annona senegalensis Pers.	0.58	4.76
Bombax costatum Pellegr. & Vuillet.	0.58	6.34
Cassia nilotica (L.) Willd.	0.58	4.76
Cassia occidendalis L.	0.58	7.93
Cleistopholis patens (Benth.) Engl. & Diels.	0.58	4.76
Cymbopogon citratus (DC.) Stapf.	0.58	3.17
Eucalyptus camaldulensis Dehnhardt.	0.58	4.76
Harungana madagascariensis Auct.	0.58	4.76
Heliotropium indicum L.	0.58	6.34
Kigelia africana (Lam.) Benth.	0.58	7.93
Newbouldia laevis (P. Beauv.) Seeman	0.58	4.76
Palisota hirsuta (Thunb.) K. Schum.	0.58	9.52
Paullinia pinnata L.	0.58	6.34
Pterocarpus erinaceus Poir.	0.58	6.34
Rauvolfia vomitoria Afzel.	0.58	6.34
Vitellaria paradoxa C.F.Gaertn.	0.58	4.76

Note: RFC = Relative frequency of citation; CPr = Contribution of plants in recipes

Table 5. Consensus and floristic richness in the treatment of symptoms associated with tuberculosis in the District of Abidjan, Côte d'Ivoire

Symptoms treated	Number of species used	ICF	Plant species mentioned
Chronic coughs	41	0.84	*Alchornea cordifolia*, *Terminalia brownii*, *Palisota hirsuta*, *Khaya senegalensis*, *Scoparia dulcis*, *Paullinia pinnata*, *Cassia occidentalis*,
Fever	38	0.82	
Asthenia (exaggerated fatigue)	37	0.80	*Heterotis rotundifolia*, *Ficus sur*, *Zanthoxylum zanthoxylloides*,
Bloody cough	26	0.80	*Annona muricata*, *Abrus precatorius*, *Vitellaria paradoxa*, *Terminalia*
Muscle aches	32	0.78	*glaucescent*, *Cleistopholis patens Morinda lucida*, *Nephrolepsis*
Chest pain	27	0.73	*bisserata*, *Bombax costatum*, *Bidens pilosa*, *Piliostigma thonningii*,
Nocturnal sweating	6	0.61	*Rauvolfia vomitoria*, *Ricinodendron heudelotii*, *Pterocarpus*
Chronic weight loss	26	0.60	*erinaceus*, *Bridelia ferruginea*, *Ageratum conyzoides*, *Kigelia*
Loss of appetite	13	0.56	*africana*, *Trema orientalis*, *Heliotropium indicum*, *Harungana*
Weakness	10	0.33	*madagascariencis*, *Parkia biglobosa*, *Eucalyptus camaldulencis*,
A general feeling of discomfort	3	0.11	*Crossopteryx febrifuga*, *Ocimum gratissimum*, *Cymbopogon citratus*, *Ceiba pentandra*, *Spondias mombin*, *Desmodium adscendens*, *Annona senegalensis*, *Citrus aurantifolia*, *Newbouldia laevis*, *Cassia nilotica*.

Note: ICF = Informant Consensus Factor

Among the species listed, phanerophytes are the most numerous (80.49%). These results reflect the state of the vegetation of tropical and equatorial zones, whose proportion in phanerophytes is estimated between 80 and 90% (Koko et al. 2009; Ambé et al. 2015). Regarding morphological types, the high frequency of shrubs (43.90%) would be explained by the fact that shrubs are frequently found in users' immediate environment, and one has easy access to the organs (Gnagne et al. 2017). Finally, the proportions of the species' phytogeographic distribution recorded the predominance from the Sudan-Zambezi zone (41.46%). On the other hand, species from the Sudano-Zambezian and Guinean-Congolian transition zone are regularly used in phytotherapy by Ivorian practitioners (Dro et al. 2013).

The analysis of the specific frequency of quotation and their contribution in the different recipes shows that *A. cordifolia*, *H. rotundifolia*, *Z. zanthoxylloides*, *K. senegalensis*, *O. gratissimum*, *A. conyzoides*, and *B. pilosa* are the most quoted species. Which is also the most used in the different recipes to treat pulmonary tuberculosis by the herbalists in Abidjan. However, most other species listed seem to be more or less known, given their frequency of quotation and their contribution to the different recipes, which are not negligible. This could be explained by the diversity of species used in the different treatments of symptoms, and the combination of several plants or organs could reinforce the healing power of the preparations.

Leaves are the most used organs (44.63%), followed by barks and roots. The predominance of leaves in recipes by practitioners could be justified by the abundance of chemical groups they contain, as they are known as the site of synthesis of secondary plant metabolites (Lumbu et al. 2005). Authors such as Zirihi (1991) and Diatta et al. (2013) have also shown that leaves are the most used plant organs in traditional medicine to treat various ailments. All of these organs mentioned above are prepared mainly by decoction. Decoction allows for the collection of the most active ingredients and mitigates or negates the toxic effect of some recipes (Salhi et al. 2010). These preparations are all prescribed as a drink or oral route. This prescription can be explained by the disease being related to bacterial infections localized in the deep organs. Therefore, to reach them, any compound must pass through the digestive system to facilitate assimilation and action (Tra et al. 2008).

This study has shown that multi-specific recipes (100%) are the most used to treat tuberculosis and associated symptoms. This could be explained by the fact that the association of plants reinforces the activity of the remedies. In addition, it allows creating a dynamization of the curative effects of various constituents to achieve a therapeutic synergy fighting both the bacteria responsible for the disease and also acting against certain symptoms such as fatigue, lack of appetite, fever, etc. (Betti 2003; Bla et al. 2015). This study researched the Ivorian flora for plant species used against tuberculosis and associated symptoms. These surveys revealed a diversity of 41 plant species belonging to 26 families. Fabaceae (14.63%), Annonaceae (7.32%), and Euphorbiaceae (7.32%) are the most represented. The level of knowledge of the plant species used against this pathology and its associated symptoms varies from one species to another, being higher for *A. cordifolia*. As a result of this survey, six plants species, i.e., *N. bisserata*, *V. paradoxa*, *T. glaucescens*, *A. cordifolia*, *F. sur*, and *K. africana*, are commonly used in combination in the treatment of tuberculosis and its associated symptoms.

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