Ethnobotanical study of plants with anti-tuberculosis properties from the traditional pharmacopoeia of Zuénoula, Central-Western Côte d'Ivoire

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Research

Abstract

Background: In Zuénoula, a town located to West-Central of Côte d'Ivoire, traditional medicine is often used to treat tuberculosis. However, the recipes proposed by the traditional practitioners against the disease remain a secret to the scientific community. This study exposes indigenous knowledge from traditional practitioners of Zuénoula to contribute in the search for new anti-tuberculosis recipes based on traditional medicine.

Methods: A total of 87 indigenous traditional practitioners in Zuénoula were interviewed using questionnaires on plants used to combat tuberculosis. This study was carried out from August 5 to December 31, 2024. The frequency of citation of species (FCe) and Therapeutic use value (VUT) were calculated to assess the interviewees' responses. The results were analyzed using SPSS 20 software.

Results: A total of 28 plant species were indicated by the respondents as plants with anti-tuberculosis properties. The analysis of indices evaluated, showed six plants well cited and regularly exploited by the traditional practitioners of Zuénoula in the fight against tuberculosis. These are: *Kleinhovia hospita* (FCe = 0.09 ; VUT= 3.88), *Irvingia gabonensis* (FCe = 0.09 ; VUT= 3.02), *Tristemma coronatum* (FCe = 0.07 ; VUT= 2.95), *Allium cepa* (FCe = 0.06 ; VUT= 2.67), *Sterculia setigera* (FCe = 0.06 ; VUT= 2.04) and *Persea americana* (FCe = 0.06 ; VUT= 1.45).

Conclusions: This study is a contribution in the search for new solutions against tuberculosis in Côte d'Ivoire and particularly in Zuénoula, a city of the country strongly affected by the disease.

Keywords: Ethnobotany, Medicinal plants, Tuberculosis, Zuénoula, Côte d'Ivoire

Background

Since the beginning of humanity, about 7 million years ago (Guy 2009), the softening properties of medicinal plants have helped keep humans healthy (Sidio & N'guessan 2019). This traditional knowledge remains relevant despite the progress of modern medicine (Koné & Kamanzi 2006). The multiple and intense interactions between the plant world and humans have led to the rise of a new science related to botany and known as ethnobotany. Ethnobotany is therefore a science that studies the use of plants by humans in the history of a society and in a given geographical setting (N'guessan 2008). It therefore includes traditional medicine, based on the empirical use of plants for health purposes (Ta *et al*. 2023).

In Côte d'Ivoire, a West African country, nearly 80% of the population resorts, as a first-line treatment, to traditional medicine and remedies from traditional pharmacopoeia to deal with health problems (Doh *et al*. 2023). This observation can be explained by the culture of the Ivorian people and especially by the insufficient number of health structures in the country. Traditional medicine, which is in high demand, offers solutions to several problems of the population. Tuberculosis, the subject of this study, is well known among these practitioners of this medicine based on ancestral knowledge. Tuberculosis is a contagious, endemic-epidemic disease, mainly transmitted between humans due to the complex of *Mycobacterium tuberculosis*, *Mycobacterium africanum* and *Mycbacterium bovis* (Issabré 2019). It is a disease that generally affects the lungs and manifests itself by prolonged cough, chest pain, asthenia, intense fatigue, weight loss, fever and night sweats (WHO 2024). According to WHO report on tuberculosis, 1.25 million people died worldwide from the disease in 2023. Southeast Asia and Africa are the two most affected geographical areas since they alone account for more than two thirds of cases (Blanc 2023). Tuberculosis is also the leading cause of death for people infected with HIV. In modern medicine, treatment of the disease is based on the administration of antibiotics, the most common of which are: isoniazid, rifampicin, pyrazinamide and ethambutol (Sharma &Yadav 2017). In Côte d'Ivoire, 21,000 cases of tuberculosis are recorded each year, or 23 cases per 100,000 inhabitants (PNLT 2024). Tuberculosis therefore remains a public health problem despite the government's efforts. This observation is due to the still incomplete health coverage in the country and especially to bacterial resistance to the pharmaceutical products administered.

In the department of Zuénoula, the site of this study, the health authorities reported 1,300 cases in 2023 for a population estimated at 80,000 inhabitants (PRLT 2024). Faced with this public health problem, tuberculosis patients frequently turn to traditional healers in the city. However, the plants and recipes administered by traditional healers remain a secret to the scientific community. This study responds to this concern. It lifts the veil on the indigenous knowledge of traditional healers to contribute to the search for new anti-tuberculosis recipes based on traditional medicine. Specifically, it makes an inventory of plant species against tuberculosis by traditional practitioners of Zuénoula and presents the proposed medicinal recipes.

Materials and Methods

Study area

Zuénoula or Zouenoula is a city located in the Center-West of Côte d'Ivoire belonging to the Marahoué region (Figure 1). It is located 367.2 km from Abidjan, the economic capital of the country, with the geographical coordinates of 7 ° 25'45 '' N and 6 ° 02'35 W. It is a city populated by approximately 80,000 inhabitants, mainly indigenous people of the Gouro ethnic group (RGPH 2018).

Ethnobotanical survey and plant identification

The investigations on anti-tuberculosis plants took place from August 5 to December 31, 2024, with the indigenous traditional practitioners of Zuénoula. The list of traditional practitioners was provided by the city municipality. We met the traditional practitioners by appointment, sometimes at their home and sometimes at their workplace. Each respondent was interviewed on the basis of a previously prepared survey form. The questionnaire was related to the plants proposed against tuberculosis, the different organs used, the techniques of preparation and administration of medicinal recipes.

In relation to the identification of plant species, it was done by the botanical experts of the National Center of Floristics (CNF) of the University Félix Houphouet-Boigny of Abidjan, Côte d'Ivoire. The scientific names and families of the plants were assigned in accordance with APG III (2009). The voucher specimens were recorded and deposited in CNF.

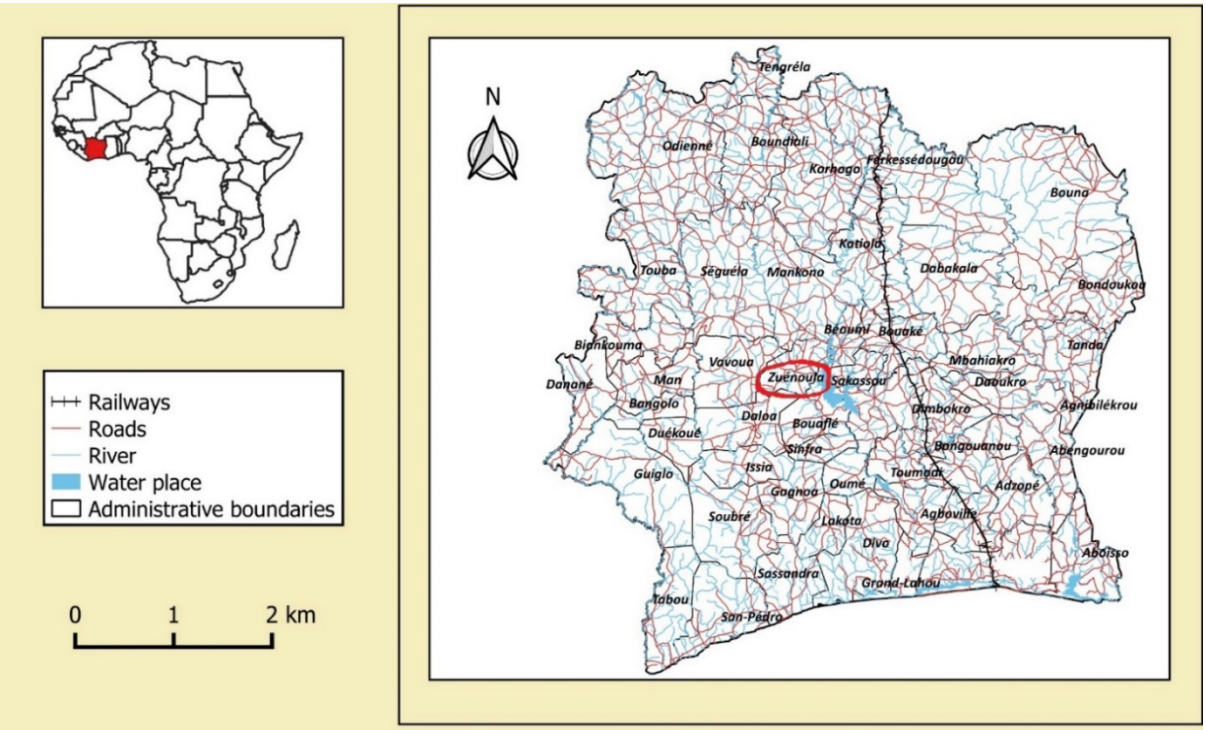

Figure 1. Location of the city of Zuénoula in Côte d'Ivoire and Africa

Cultural significance indices assessed

Two indices of cultural importance were evaluated to assess the knowledge and uses of the plants proposed by the traditional pharmacopoeia of Zuénoula. These are : the frequency of citation and the value of use in therapy.

Frequency of citation of plant species (FCe)

The frequency of citation of species (FCe) refers to the ratio between the number of respondents who mentioned the species and the total number of people interviewed during the survey. The FCe formula is mathematically established as follows (Fah *et al*. 2013, Doh 2015):

$$\mathrm{FCe} = \frac{number\ of\ citations\ of\ a\ plant\ species}{Total\ number\ of\ citations\ of\ all\ plant\ species}$$

Therapeutic use value (VUT)

The VUT is an adaptation of the use value (VU). It is taken from the mathematical formula of Camou-Guerrero *et al*. (2008). In this study, it allows us to significantly determine the extent of the use of each plant compared to others. It is established as follows:

$$\mathrm{VUT} = \frac{\mathrm{n}\sum \mathrm{Si}}{\mathrm{ni}}$$

With VUT: Therapeutic Use Value

S: the use score assigned by respondent i between 1 and 4

n : number of respondents.

The very highly requested species have VUT included in the interval]3; 4]. Those whose VUT are included in the intervals] 2.5; 3],] 2; 2.5] and [1; 2] are said to be highly solicited, weakly solicited and very weakly solicited respectively.

Data analysis

Ethnobotanical indices were analyzed using SPSS 20 software. The analysis allowed for a hierarchical classification through a dendrogram based on FCe values. To design the dendrogram, the listed plants were renamed according to the Bayer code using the first three letters of the genus and the first two letters of the species (Ta *et al*. 2025). The construction of Histograms in this study required Excel 2016 software.

Results

Socio-demographic profile of respondents

Ethnobotanical investigations in the city of Zuénoula allowed us to interview 87 people working in the field of traditional medicine. The respondents are all of Ivorian nationality and of the Gouro ethnic group, originally from the region. There were 49 men and 38 women. The majority of these interviewees had a primary education level (Figure 2).

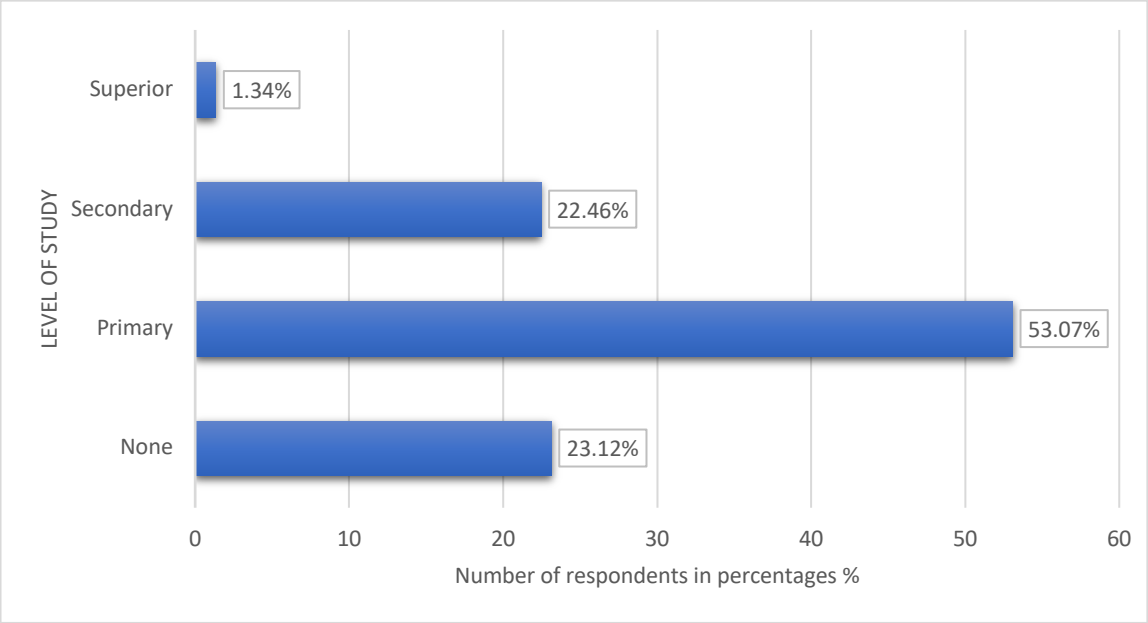

Figure 2. Distribution of the number of respondents according to study level

Directory of plants and ethnomedicinal characteristics

The survey focused on plants with anti-tuberculosis potential has made it possible to list 28 plant species. The listed plants and their ethnomedicinal characteristics are recorded in Table 1.

Table 1. List of plants and medicinal characteristics

Plant species, Voucher numbers	**Part of plant used**	**Preparation techniques**	**Administration methods**	**VUT**	**FCe**
Allium cepa L. (Amaryllidaceae), **TBH038**	Bulb	decoction	Drink	2.67	0.06
Costus afer Ker Gawl. (Costaceae), **TBH041**	Root	Decoction	Drink Purge	2.05	0.01
Disocorea bulbifera L. (Dioscoreaceae), **TBH045**	Whole plant	Maceration	Drink	1.03	0.01
Dorstenia turbinata Engl. (Moraceae), **TBH047**	Leafy stem	Decoction	Drink purge	1.23	0.02
Epipremnum pinnatum (L.) Engl. (Araceae), **TBH050**	Whole plant	Maceration	Drink	2.18	0.02
Euphorbia hirta L. (Euphorbiaceae), **TBH052**	Leafy stem	Decoction	Drink Purge	2.79	0.02
Irvingia gabonensis Baill. (Irvingiaceae), **TBH054**	Leaves	Decoction	Drink	3.02	0.09
Keetia mannii (Hiern) Bridson (Rubiaceae),**TBH057**	Leaves	Decoction	Purge	1.01	0.02
Khaya ivorensis A. Chev. (Meliaceae), **TBH061**	Leaves	Decoction Kneading	Drink Purge	2.48	0.02
Kleinhovia hospita L. (Malvaceae), **THB065**	Leaves	Decoction	Drink	3.88	0.09

Lasia spinosa (L.) Thw. (Araceae), **TBH068**	Leafy stem	Maceration	Drink	1.56	0.02
Morinda citrifolia L. (Rubiaceae), **TBH072**	Leaves	Decoction	Drink	1.05	0.02
Musa acuminata Colla (Musaceae), **TBH075**	Root	Trituration	Consumption with lemon juice	1.02	0.02
Newbouldia laevis (P.Beauv.) Seem. (Bignoniaceae), **TBH076**	Leaves	Decoction	Drink	1.98	0.03
Paullinia pinnata L. (Sapindaceae), **TBH080**	Leafy stem	Decoction	Drink with honey	2.98	0.05
Pavetta corymbosa (DC) F.N. Wlliams (Rubiaceae),**TBH083**	Root	decoction	Drink wih limon juice	1.27	0.04
Peperomia pellucida (L.) Kunth (Piperaceae), **TBH085**	Leafy stem	Maceration	Drink	2.12	0.03
Persea Americana Mill. (Lauraceae), **TBH088**	Root	Decoction	Drink	1.45	0.06
Periploca nigrescens Afzel. (Apocynaceae), **TBH092**	Whole plant	Decoction Kneading	Drink Purge	1.36	0.03
Picramnia pentandra Sw. (Picramniaceae), **TBH097**	Leafy stem	Decoction	Drink	1.25	0.03
Picnanthus angolensis L. (Myristicaceae), **TBH099**	Leaves	Decoction	Drink	2.69	0.05
Picralima nitida (Stapf) T.Durand & H.Durand (Apocynaceae), **TBH103**	Root	Decoction	Drink Purge	1.01	0.01
Piper nigrum L. (Piperaceae), **TBH107**	Leaves	Decoction Trituration	Drink Purge	1.08	0.02
Sarcocephalus latifolius (Sm.) Bruce (Piperaceae), **TBH078**	Leaves	maceration	Drink Purge	2.56	0.02
Solanum torvum Sw. (Solanaceae), **TBH112**	Leafy stem	Trituration	Drink with limon juice	2.23	0.04
Sterculia setigera Delile (Malvaceae), **TBH117**	Leaves	Decoction	Drink	2.04	0.06
Tristemma coranatum Benth. (Melastomataceae), **TBH121**	Leafy stem	Decoction	Drink	2.95	0.07
Zingiber officinale Roscoe (Zingiberaceae), **TBH125**	Stem	Kneading	Consumption Purge with lukewarm water	1.85	0.03

Frequency of citation for plant species (FCe)

The values of FCe are recorded in Table 1. Their statistical treatment made it possible to make a hierarchical classification of inventoried plant species (Figure 3).

The dendrogram classified the listed plants into three classes with a cluster distance of 3. The first class is composed of six plant species: *Tristemma coranatum* Benth. (Melastomataceae), *Allium cepa L.* (Amaryllidaceae), *Sterculia setigera* Delile (Malvaceae), *Persea americana* Mill. (Lauraceae), *Kleinhovia hospita L.* (Malvaceae) and *Irvingia gabonensis* Baill. (Irvingiaceae). The second class is made up of 13 plants that were mentioned moderately, while the fourth class is composed of nine plants that were rarely mentioned by respondents to the ethnomedicinal survey.

Therapeutic Use Value (VUT)

The VUT are also recorded in Table 1. According to the VUT values, the plant species were divided into five groups (Figure 4). Two highly exploited plants are distinguished: *Kleinhovia hospita* and *Irvingia gabonensis*. Four other plants are heavily exploited: *Tristemma coronatum*, *Allium cepa*, *Sterculia setigera*, and *Persea americana*. This section indicates that the six most cited plants are the most widely used in anti-tuberculosis recipes.

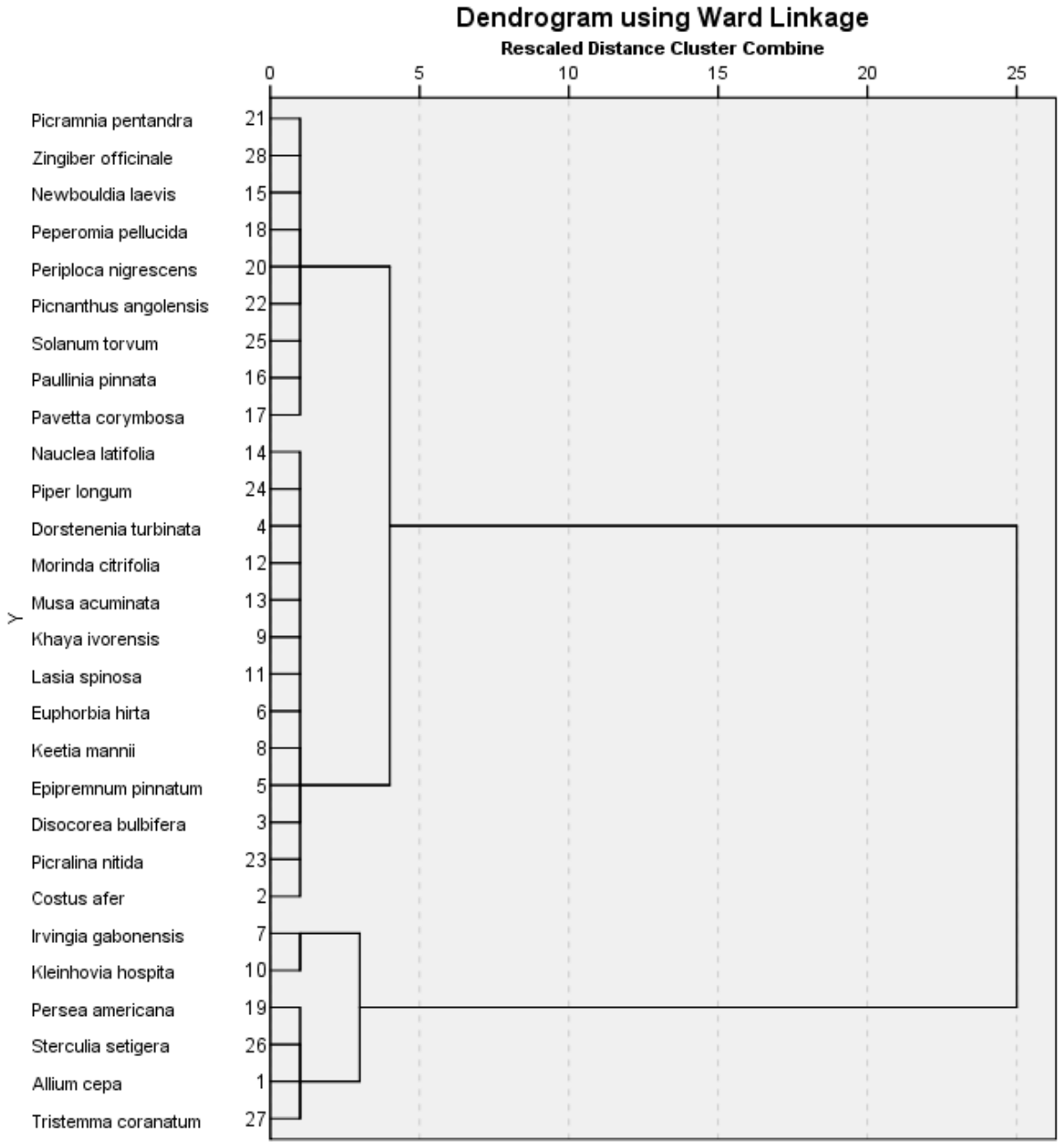

Figure 3. Dendrogram of hierarchical classification of plants listed according to FCe

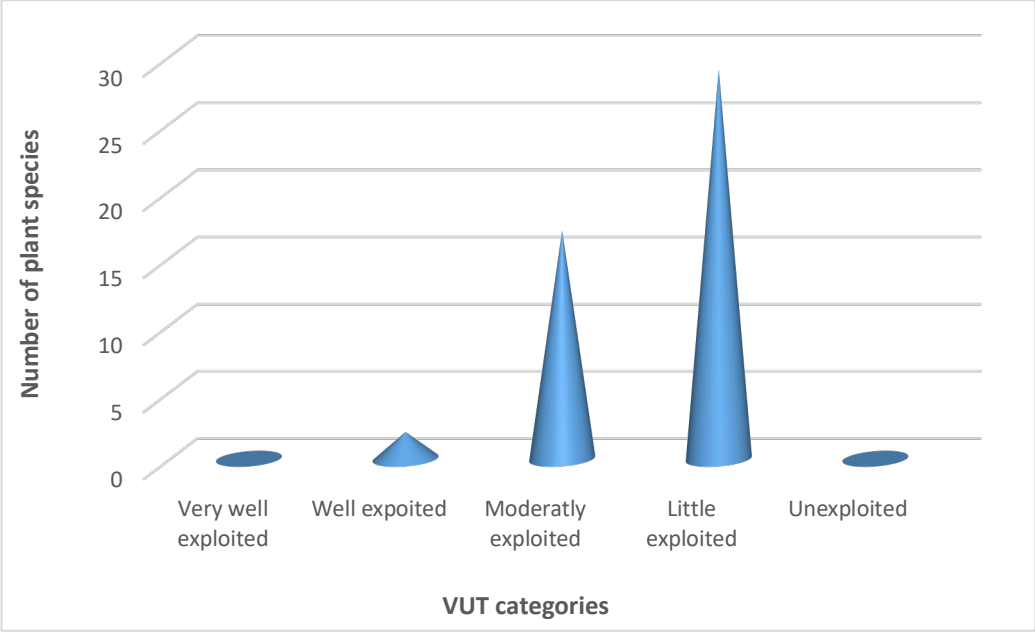

Figure 4. Histogram of distribution of inventoried plant species according to VUT

Plant parts used

The parts of the plants used in the preparation of herbal medicines are: leaves (35.71%), leafy branches (28.57%), roots (17.85%), whole plants (10.71%), bulbs (3.57%), and stems (3.57%). Leaves predominate in medicinal recipes (Figure 5).

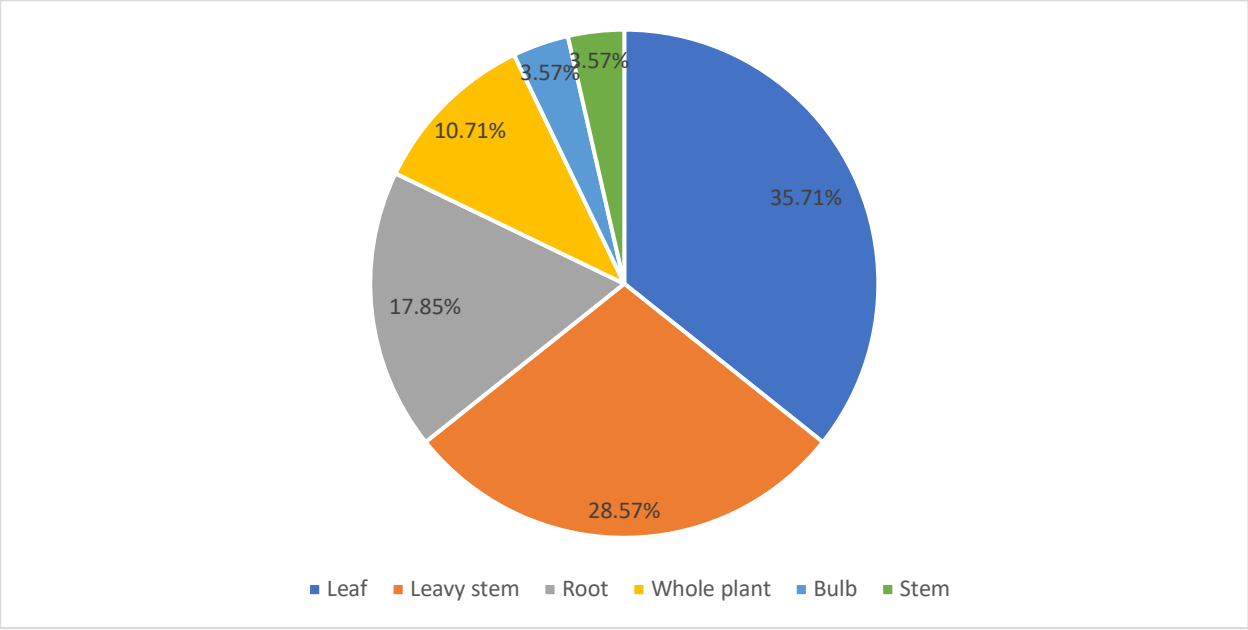

Figure 5. Distribution spectrum of plant parts used

Preparation techniques

The investigations reveal four preparation techniques used by traditional practitioners in Zuénoula: decoction, maceration, kneading, and trituration (Figure 6). According to the figure, decoction (64.51%) is the most commonly used preparation technique, followed by maceration (16.12%), with trituration and kneading representing 9.67% each. Decoction is predominant.

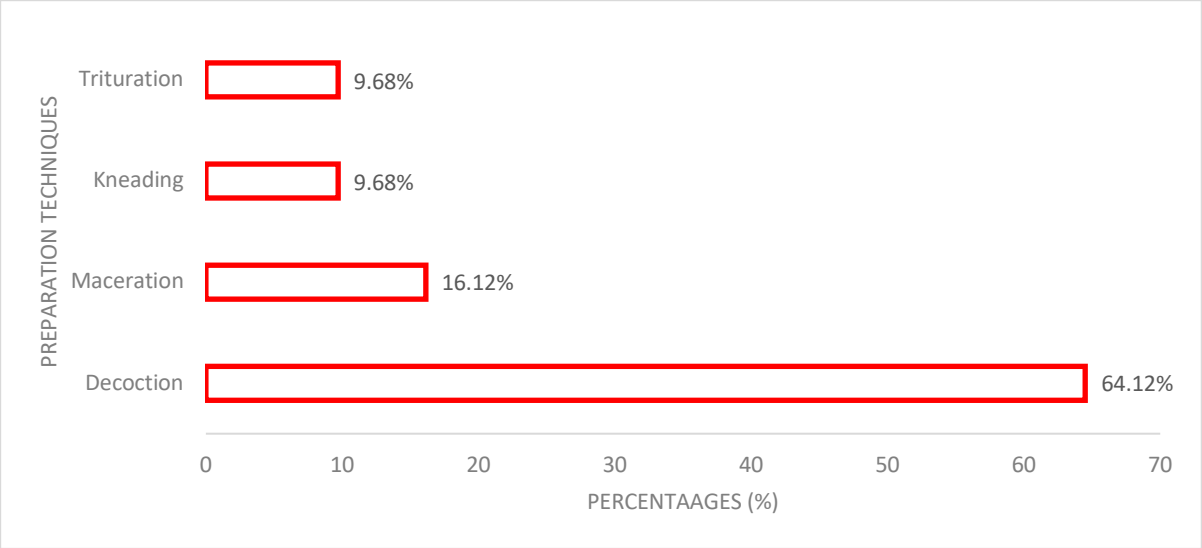

Figure 6. Histogram of the distribution of preparation techniques

Administration methods

Regarding the administration methods, the study reveals three different methods (Figure 7): drinking (64.10%), purging (30.76%), and consuming the phytomedicine as food (5.12%). Drinking is the most common method.

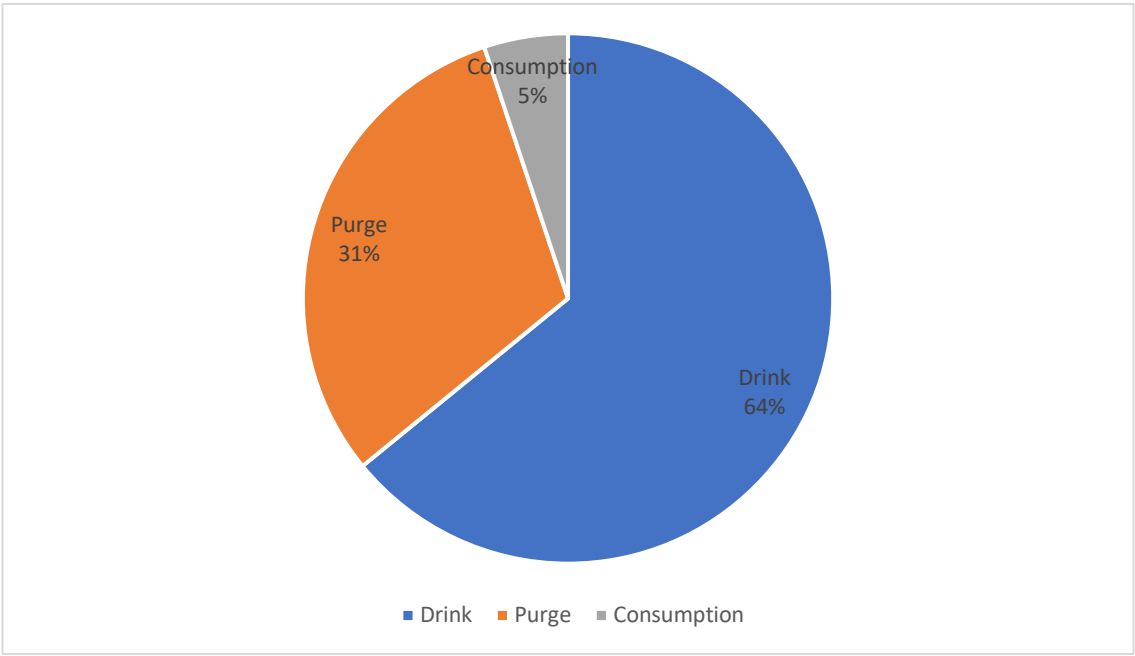

Figure 7. Spectrum of distribution of phytomedicine administration methods

Discussion

Socio-demographic profile of respondents

This section shows that women were well involved in the practice of traditional medicine in Zuenoula although their number remained low compared to men. This profile of traditional practitioners has already been observed in Zuenoula by Gnagne *et al*. (2017) in their study on diabetes. Furthermore, Orch *et al*. (2015) also noted the predominance of men among traditional practitioners.

Directory of plants and ethnomedicinal characteristics

In this list of plants, five plant species have already been indicated as plants with anti-tuberculosis potential in the African pharmacopoeia: *Euphorbia hirta* L. (Euphorbiaceae) (Mann *et al*. 2007), *Sterculia setigera* Delile. (Malvaceae) (Babalola *et al*. 2012), *Allium cepa* L. (Amaryllidaceae), *Piper nigrum* L. (Piperaceae) and *Zingiber officinale* Roscoe. (Zingiberaceae) (Eddouks

et al. 2020). The other 23 plants are revealed by this study and show the diversity of plants used against tuberculosis in traditional medicine of Zuénoula.

Therapeutic Use Value (VUT)

These results show that plants do not have the same cultural importance in African pharmacopoeia. However, these most exploited plants will be subject to significant anthropogenic pressure in the environment (Sidio & N'guessan 2019). However, they should attract the attention of the scientific community in the search for new molecules capable of combating tuberculosis and its variants.

Plant parts used

This section reveals the predominance of leaves in medicinal recipes. This observation has already been made by Orsot (2016), Ta (2017), and Ambé *et al*. (2015) in surveys on medicinal plants in Côte d'Ivoire. The high use of leaves in medicinal recipes could be explained by the accessibility of these organs (N'guessan *et al*. 2009).

Preparation techniques and administration methods

Decoction is the most commonly used preparation technique by traditional practitioners in Zuénoula. This finding corroborates several research studies: Ghourri *et al*. (2013), Gbekley *et al*. (2015), and Béné *et al*. (2016), which have shown that decoction is the most frequently used preparation method in similar studies. This is a positive finding because decoction contains the most active ingredients and reduces the toxicity of plant species (Soro *et al*. 2021).

Concerning adminstration methods, drinking is the most used. N'Guessan *et al*. (2009) and Ta & N'guessan (2021) have indicated this method of administration as the predominant method in similar studies.

Conclusion

The study was conducted in the city of Zuénoula, a town in west-central of Côte d'Ivoire. It interviewed 87 traditional practitioners and inventoried 28 plant species involved in the treatment of tuberculosis according to the traditional pharmacopoeia of the town.

The parts of the plant used in the preparation of anti-tuberculosis recipes are : leaves, leafy stems, roots, whole plants, bulbs, and stems. Four techniques are used in the preparation of these herbal medicines: maceration, crushing, and kneading, with the predominating of decoction. The phytomedicines are administered mainly by drink, sometimes by purging or through food consumption.

The analysis of the socio-cultural indices evaluated (FCe and VUT) revealed six well-cited plants regularly used by traditional practitioners in Zuenoula in the fight against tuberculosis. These are : *Tristemma coronatum*, *Allium cepa*, *Sterculia setigera*, *Persea americana*, *Kleinhovia hospita*, and *Irvingia gabonensis*.

This study clearly shows that traditional practitioners in the town of Zuenoula offer recipes for tuberculosis. This is a significant aid in the fight against the disease in Côte d'Ivoire. However, traditional practitioners do not use laboratory tests to confirm or infirm out the disease, they could confuse tuberculosis with a simple cough because they base their diagnosis only on subjective symptoms. To overcome this inadequacy, the results of this study, once published, will be made available to the Ministry of Health of Côte d'Ivoire with the agreement of interviewees to encourage strong collaboration between modern medicine and traditional medicine in the fight against tuberculosis. It is this synchronization of efforts that will be able to eradicate tuberculosis throughout the country and especially in the town of Zuénoula, which presents an alarming situation for tuberculosis cases.

Declarations

List of abbreviations: CNF - National Center of Floristics; Fce - Frequency of citation of plant species; TB - Tuberculosis; VUT - Therapeutic Use Value; WHO - World Health Organisation

Ethics approval and consent to participate: All people who participated in this study gave their free consent. No further ethics approval was required.

Consent for publication: Not applicable

Availability of data and materials: Not applicable

Competing interest: Not applicable

Fuding: Not applicable

Author contributions: B.I.H.T. collected the data, analyzed, and wrote the text. Y.D.G. participated in data collection and analysis. S.C.P. supervised the study and helped with the writing of the manuscript.

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Appendix 1. List of plants with botanical characteristics

Plant species	Botanical Families	Vernacular names (from Gouro ethnic group of Zuenoula)	Chorology (phytogeographic zones)	Biological types	Morphological forms	Periodicity
Allium cepa L.	Amaryllidaceae	Djabalou	GC-SZ	np	Herb	Annual
Costus afer Ker Gawl.	Costaceae	Dongôô	GC	np	Herb	Perennial
Disocorea bulbifera L.	Dioscoreaceae	Lolouya	GC-SZ	mp	Liana	Annual
Dorstenia turbinata Engl.	Moraceae	Pétaninyri	GCW	mp	Tree	Perennial
Epipremnum pinnatum (L.) Engl.	Araceae	Yripôô	I	mp	Bush	Perennial
Euphorbia hirta L.	Euphorbiaceae	Blanyi	GC-SZ	Ch	Herb	Annual
Irvingia gabonensis Baill.	Irvingiaceae	Karou	GC	Mp	Tree	Perennial
Keetia mannii (Hiern) Bridson	Rubiaceae	Folibla	GC	Mp	Bush	Perennial
Khaya ivorensis A. Chev.	Meliaceae	Tchalouyri	GC	Mp	Tree	Perennial
Kleinhovia hospita L.	Malvaceae	Goliwrèyri	GC	Mp	Tree	Perennial
Lasia spinosa (L.) Thw.	Araceae	Koliodinhin	GC-SZ	np	Bush	Perennial
Morinda citrifolia L.	Rubiaceae	Blèdinhin	GC-SZ	mp	Shrub	Perennial
Musa acuminata Colla	Musaceae	Mihiyri	I	Geop	Herb	Perennial
Newbouldia laevis (P.Beauv.) Seem.	Bignoniaceae	Srèguiyri	GC	mp	Shrub	Perennial
Paullinia pinnata L.	Sapindaceae	Folibalii	GC-SZ	mp	liana	Annual
Pavetta corymbosa (DC) F.N. Wlliams	Rubiaceae)	Zinhinyri	GC-SZ	Mp	Tree	Perennial
Peperomia pellucida (L.) Kunth	(Piperaceae	Gbèlalou	GC	mp	Herb	annual
Persea Americana Mill.	Lauraceae	Voayri	I	Mp	Tree	Perennial
Periploca nigrescens Afzel.	Apocynaceae	Oubali	GC	mp	Liana	Annual
Picramnia pentandra Sw.	Picramniaceae	Bèlouyri	GC	mp	Shrub	Perennial
Picnanthus angolensis L.	Myristicaceae	Goalayri	GC	mP	Tree	Perennial
Picralima nitida (Stapf) T.Durand & H.Durand	Apocynaceae	Gbôlouyri	GC	mP	Tree	Perennial
Piper nigrum L.	Piperaceae	Srobali	GC	Ep	Liana	Perennial
Sarcocephalus latifolius (Sm.) Bruce	Rubiaceae	Pkonin	GC-SZ	mp	Shrub	Perennial
Solanum torvum Sw.	Solanaceae	Pôhôlôdin	GC	np	Shrub	Perennial
Sterculia setigera Delile	Malvaceae	Palininyri	GC	np	Bush	Perennial
Tristemma coranatum Benth.	Melastomataceae	Golilou	GC-SZ	mp	Herb	Annual
Zingiber officinale Roscoe	Zingiberaceae	Gnamakoulou	GC-SZ	np	Herb	Annual

Legend:

Biological types: np = nanophanerophyte, mp = microphanerophyte, mP = mesophanerophytes, Mp = megaphanerophytes, Geop = geophyte, Ep = epiphyte

Chorology: I = Introduced species in Côte d'Ivoire, GC = species from Guineo-Congolese zone, SZ = species from Sudano-Zambesian zone**,** GC-SZ = species endemic to Guineo-Congolese and Sudano-Zambesian zones, GCW = species endemic to West-African forests