



Medicinal plants from the sacred forest of Zadepleu, Man, western Côte d'Ivoire: Ethnomedicinal survey and phytochemical screening

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Abstract

The ethnomedicinal study was undertaken to assess the medicinal benefits of the Zadepleu Sacred Forest for the local population. It identified 32 species used by the local population. The parts of these plants used in medicinal recipes are: leaves and leafy twigs (55%), bark (24%), roots (17%), and fruits and seeds (4%). The leaves are the most commonly used organs (70%). The preparation techniques are: decoction (60%), kneading (25%), and trituration (15%). The preferred method of administration of these phytomedicines is drinking (56%). The calculated Citation Frequencies (FC) revealed five species most commonly used in medicinal recipes: *Costus afer*, *Ricinodendron heudelotii*, *Khaya ivorensis*, *Solanum torvum*, and *Terminalia ivorensis*. A phytochemical screening was performed on the organs of these five plants. The results indicated the absence of quinone substances in the various plant species and the presence of saponins and alkaloids in all the plant organs analyzed. These chemical groups resulting from secondary metabolism in plants could justify the empirical use of these plants in traditional medicine. The sacred forest of Zadepleu is therefore of undeniable importance to local populations given its essential contribution to the good health of local populations.

Keywords: Ethnomedicinal survey; Sacred forest; Plants; Zadepleu; Man; Côte d'Ivoire

1. Introduction

Côte d'Ivoire is facing the continued destruction of its forest cover [1]. To curb this deforestation, the Ivorian government has decided to manage, protect, and rehabilitate classified forests and, since 1992, has entrusted this mission to the Forest Development Company (SODEFOR). In 2002, the government added the Ivorian Office of Parks and Reserves (OIPR), which is responsible for the sustainable management of national parks and reserves. In addition to these state structures, culturally protected areas known as sacred forests exist in several localities across the country with the same goal of protecting biodiversity. Due to their sacred nature, these village forest areas are rarely attacked and constitute an important reserve of plant resources [2]. They are therefore regularly visited by local populations only to stock up on fruits for food and to collect plant samples for medical care [3]. The sacred forest of Zadepleu is not on the margins of this situation. It is the main source of food products from wild spontaneous plants and especially the reservoir of medicinal plants for the surrounding populations. However, these plant species from the said forest, used in traditional medicine by the populations of Zadepleu, remain unknown to the general public, in a country where 80% of the population uses plant species for treatment [4]. This study aims to popularize plants from the sacred forest of Zadepleu used in traditional medicine. It makes an inventory of these medicinal plants based on an ethnomedicinal survey among the population of Zadepleu, owners of the said forest. She also researches the scientific basis of the traditional use of these plant species through phytochemical screening.

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2. Material and Methods

2.1. Presentation of the Study area

The Sacred Forest of Zadepleu is an eight-hectare forest belonging to the village domain located in the prefecture of Man between latitudes 7.416° North and 7.591° West. The city of Man is in the far west of Côte d'Ivoire. It is the capital of the Mountain District and the Tonkpi region.

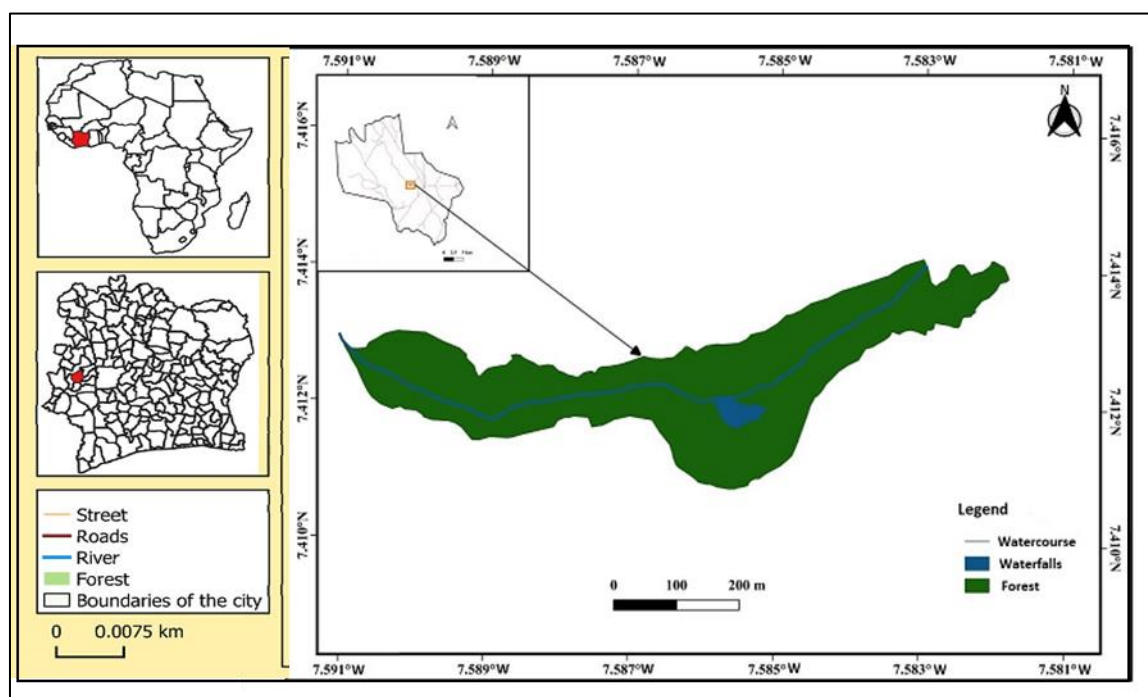


Figure 1 Location of the sacred forest of Zadepleu in Côte d'Ivoire and Africa

2.2. Study Material

The plant material consisted of all the plant species identified during the ethnomedicinal survey from the sacred forest of Zadepleu. The survey required technical equipment consisting of a survey form, pruning shears, a GPS, a digital camera, and a laptop. In addition to this plant equipment, standard laboratory equipment was used for phytochemical screening.

2.3. Plant Inventory

The floristic inventories were conducted by combining the surface survey method with the mobile survey method during the work in the sacred forest of Zadepleu. The surface survey consisted of randomly setting up 10 square plots in the forest. These plots, each 25 m long, were separated by 50 m from each other. To establish the floristic list, all species of trees, shrubs, bushes, and vines were inventoried and recorded on a floristic inventory sheet created for this purpose. For the roving survey, the entire distance (50 m) between two plots was covered in a north-south and west-east direction to record and collect as many plant species as possible.

2.4. Ethnomedicinal Survey

A series of meetings was organized with the participation of a field guide familiar with the Yacouba, an ethnic group from the village of Zadepleu. These meetings took place from February 2024 to May 2024. A total of 231 people from the village, aged over 18, were interviewed using a previously prepared survey sheet. The survey questionnaire covers plant species from the Zadepleu forest used in traditional medicine, plant organs used in medicinal recipes, various ailments treated with plants, and preparation techniques and administration methods for herbal medicines.

2.5. Identification of Listed Species

The identification of listed plants was based on various documents [5, 6, 7]. The names are given according to APG IV.

2.6. Frequency of Citation of Listed Species

The frequency of citation of species (FC) refers to the ratio between the number of respondents who mentioned the species and the total number of people interviewed during the survey [8].

$$FC = \frac{\text{Number of people who mentioned the item}(n)}{\text{Number of people surveyed } (N)}$$

2.7. Preparation of Aqueous Extracts for Phytochemical Screening

Plant organs were collected during the ethnomedicinal survey in the Zadepleu forest. They were washed with tap water and dried for 21 days in a room at 25 to 30°C. After drying, they were pulverized and powdered using an electric grinder. The resulting powder was extracted using a conventional laboratory method [9, 10]. This method involved mixing 100 g of plant organ powder in one liter (1 L) of distilled water using a blender. The resulting solution was wrung out in a square of cloth to remove plant debris and filtered twice through cotton wool to further remove any debris that may have passed through the mesh. A final filtration was performed on Whatman paper. The filtrate, free of plant remains, was oven-dried at 50°C for five days. The resulting powder was coded according to the name of the plant species. The plant extracts were stored in hermetically sealed sterile containers and refrigerated (at 6°C) until phytochemical testing was performed.

2.8. Phytochemical Screening

The major chemical groups constituting the secondary metabolites of the plants were screened for in the aqueous extracts according to color reaction characterization methods [11]. Solutions showing positive reactions indicate the presence of the desired chemical groups in the plant extract. The reactions performed are listed in Table 2. The plants selected for these tri-phytochemical tests were those most frequently cited during the ethnomedicinal survey. These are: *Costus afer*, *Ricinodendron heudelotii*, *Khaya ivorensis*, *Solanum torvum* and *Terminalia ivorensis*.

Table 1 Different tests of phytochemical screening

Chimical groups		Reactive	Proof of positive test
Sterols et polyterpenes		Acetic anhydride, concentrated sulfuric acid	Appearance at the interphase of a purple or violet ring turning blue then green
Polyphenols		Ferric chloride FeCl ₃ (2%)	Appearance of more or less dark blue-black or green coloration
Flavonoids		Hydrochloric alcohol, Magnesium shavings, isoamyl alcohol	Release of heat then pinkish-orange or purplish coloring
Tannins	Gallic	Sodium acetate, Ferric chloride	Intense blue-black coloring
	Catechic	Formaldehyde, Concentrated hydrochloric acid	Gelatnous precipitate in large flakes
Quinone substances		Ammoniac	Appearance of a coloring from red to violet
Alcaloids	Dragendorf (D)	Solution of iodobismuthate potassium	Redish-brown precipitate
	Burchard (B)	Iodo-iodide reaction	Reddish-brown precipitate
Saponins		Foam indice	Appearance of persistent foam

2.9. Statistical analysis

The calculated citation frequencies were analyzed using SPSS 20 software. These values were used to perform a hierarchical classification using a dendrogram. SPSS 20 software was also used to classify the generated data. For this purpose, plant species were renamed according to the Bayer code. An Excel spreadsheet was used to create the graphs.

3. Results and Discussion

3.1. Ethnomedicinal Survey

The survey identified 32 plant species in the Zadepleu Sacred Forest, used by the local population for medicinal purposes. The list of species in alphabetical order and their ethnomedicinal characteristics are shown in Table 2.

Table 2 Inventoried plants and ethnomedicinal Characteristics

Especies and botanical families	Organs used	Preparation technique	Method of administration	Diseases treated
<i>Albizia adiantifolia</i> (Fabaceae)	Leaves	Decoction	Drink	Hemorrhoids, malaria
<i>Albizia lebbbeck</i> (Fabaceae)	Root	Petrissage	Purge	Stomach wound
<i>Aframomum sceptrum</i> (Zingiberaceae)	Leaves	Decoction	Drink	Cough
<i>Alchornea cordifolia</i> (Euphorbiaceae)	Root	Trituration	Purge	Hemorrhoids, malaria
<i>Alstonia boonei</i> (Apocynaceae)	Stem bark	Decoction	Drink	Malaria, headache
<i>Bligia sapida</i> (Sapindaceae)	Stem bark	Decoction, kneading	Drink, purge	Rheumatism
<i>Cassia siamea</i> (Fabaceae)	Stem bark	Decoction, kneading	Drink, purge	Hernia
<i>Ceiba pentandra</i> (Bombacaceae)	Leaves	Trituration	Purge	Constipation, fever
<i>Chromolena odorata</i> (Asteraceae)	Root	Decoction	Drink	Tooth decay
<i>Citrus limon</i> (Rutaceae)	Leaves	Trituration	Purge	Headache, fever
<i>Costus afer</i> (Costaceae)	Stem bark	Decoction, kneading	Drink, purge	Hernia, rheumatism
<i>Elaeis guineensis</i> (Arecaceae)	Leaves	Trituration	Purge	Headache, fever
<i>Heritiera utilis</i> (Malvaceae)	Stem bark	Decoction	Drink Purge	Painful periods
<i>Khaya ivorensis</i> (Meliaceae)	Leaves	Decoction	Drink	Hemorrhoids, malaria
<i>Mangifera indica</i> (Anarcadiaceae)	Leaves	Decoction	Drink	Hypertension, typhoid fever
<i>Manihot esculenta</i> (Euphorbiaceae)	Leaves	Decoction	Drink	Anemia
<i>Mimosa pudica</i> (Fabaceae)	Root	Decoction	Drink	Diarrhea
<i>Milixia excelsa</i> (Moraceae)	Root	Decoction	Drink	Malaria

<i>Morinda citrifolia</i> (Rubiaceae)	Leaves	Decoction	Purge	Malaria
<i>Morinda lucida</i> (Rubiaceae)	Leaves	Decoction	Drink	Diabetes, hypertension
<i>Musa acuminata</i> (Musaceae)	Leaves	Decoction	Drink	Hypertension, typhoid fever
<i>Myrianthus arboreus</i> (Moraceae)	Root bark	Decoction	Drink	Constipation
<i>Nesogordia papaverifera</i> (Sterculiaceae)	Leaves	Decoction	Purge	Malaria
<i>Newbouldia laevi</i> (Bignoniaceae)	Leaves	Decoction	Drink	Diarrhea
<i>Ricinodendron heudelotii</i> (Connaraceae)	Root bark	Decoction	Drink	Malaria, constipation
<i>Solanum torvum</i> (Solanaceae)	Leaves	Decoction	Drink	Anemia
<i>Terminalia ivorensis</i> (Combretaceae)	Leaves	Decoction	Drink	Childhood fever
<i>Terminalia superba</i> (Combretaceae)	Root bark	Decoction	Drink	Constipation
<i>Tithonia diversifolia</i> (Asteraceae)	Root	Decoction	Drink	Hepatitis
<i>Triplochiton scleroxylon</i> (Malvaceae)	Leaves Root	Decoction	Drink	Diarrhea, constipation
<i>Persea americana</i> (Lauraceae)	Leaves	Decoction	Drink	Diarrhea
<i>Piper guineense</i> (Piperaceae)	Fruits	Kneading	Purge	Cough, measles

This list clearly shows that the sacred forest of Zadepleu has an important contribution to the populations in terms of medicine. The calculated Citation Frequencies indicated that *Costus afer*, *Ricinodendron heudelotii*, *Khaya ivorensis*, *Solanum torvum* and *Terminalia ivorensis* are the most used in medicinal recipes. Among these plants, the medicinal use of *C. afer* has already been indicated in similar studies in Côte d'Ivoire [12]. These authors revealed the use of the plant against malaria, diarrhea and hypertension. However, the use of *C. afer* against hernia and rheumatism is specific to this study. As for the other four species: *R. heudelotii*, *K. ivorensis*, *S. torvum* and *T. ivorensis*, their therapeutic virtues have also been indicated among the Krobou people in southern Côte d'Ivoire [13]. Our results corroborate these previous studies.

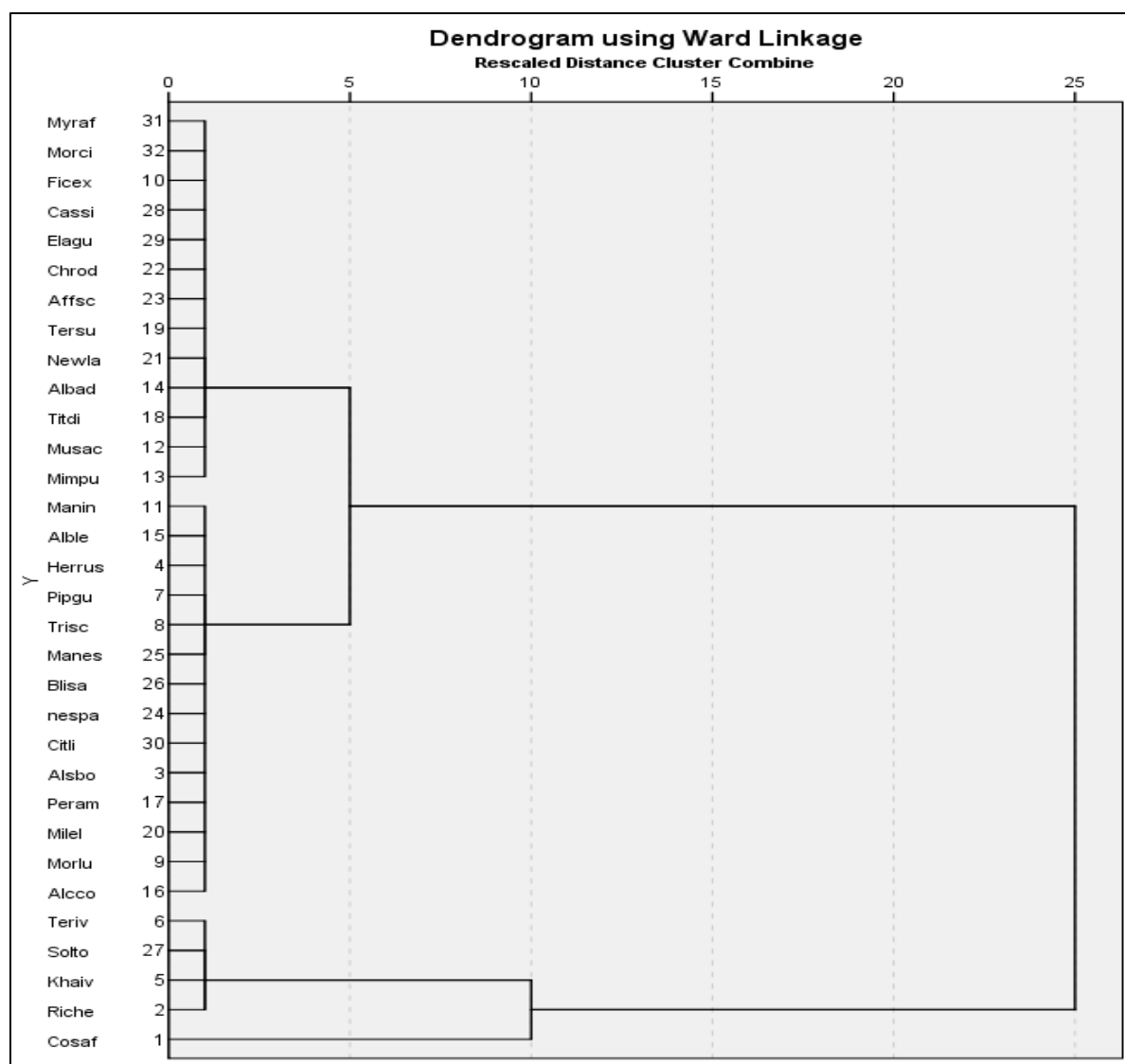
3.2. Citation frequency of listed species (FC)

The citation frequencies allowed for a hierarchical classification through a dendrogram (Figure 2). The resulting figure shows 4 groups of plants with a cluster distance of 3. The first group consists of a single plant: *Costus afer*. The second group is composed of *Ricinodendron heudelotii* (0.09); *Khaya ivorensis* (0.07); *Solanum torvum* (0.05); and *Terminalia ivorensis* (0.06). The third group is composed of 14 plants with a CF between 0.2 and 0.4. The last group consists of 13 species with citation frequencies (FC) less than 0.2. Based on the FC, it appears that *Costus afer* is the most cited plant in pharmacopoeia by the populations of Zadepleu.

3.3. Plant Parts Used, Preparation and Administration Techniques

The plant organs used, preparation techniques, and administration methods are listed in Table 2. Regarding the organs used in medicinal recipes, leaves and leafy twigs represent 55%, bark 24%, roots 17%, and fruits and seeds 4%. Leaves

are the most commonly used organs (70%). The preparation techniques are: decoction (60%), kneading (25%), and trituration (15%). The preferred method of administration of these phytomedicines is drinking (56%). The dominance of leaves in the preparation of medicinal recipes has already been revealed by several studies in Côte d'Ivoire [14]. The increasing use of leaves is justified by the fact that leaves are the site of photosynthesis, rich in chemical compounds responsible for the plant's medicinal properties [15]. For preparation techniques, decoction is the most requested with 60% response. This is explained by the fact that it collects the most active ingredient and reduces the toxicity of certain plants [16].



Cosaf- *Costus afer*; Riche- *Ricinodendron heudelotii*; Khaiv- *Khaya ivorensis*; Solto- *Solanum torvum*; Teriv- *Terminalia ivorensis*; Alcco- *Alchornea cordifolia*; Morlu- *Morinda lucida*; Milel- *Milixia excelsa*; Peram- *Persea americana*; Alsto- *Astonia boonei*; Citli- *Citrus limon*; Nespa- *Nesogordia papaverifera*; Blisa- *Bligia sapida*; Manes- *Manhiot esculenta*; Trisc- *Triplochiton scleroxylon*; Pipgu- *Piper guineense*; Herus- *Heritiera utilis*; Alble- *Albizia lebbeck*; Manin- *Mangifera indica*; Mimpu- *Mimosa pudica*; Musac- *Musa acuminata*; Titdi- *Titonia diversifolia*; Albad- *Albizia adiantifolia*; Newla- *Newbouldia laevis*; Tersu- *Terminalia superba*; Affsc- *Aframomum sceptrum*; Chro- *Chromolaena odorata*; Elagu- *Elais guinensis*; Cassi- *Cassia siamea*; Ficex- *Ficus exasperata*; Morci- *Morinda citrifolia*; Myraf- *Myrianthus arboreus*

Figure 2 Dendrogram of classification of inventoried plants according to FC

3.4. Phytochemical Screening

Five plants had good FC values: *Costus afer*. The second group consisted of *Ricinodendron heudelotii*, *Khaya ivorensis*, *Solanum torvum* and *Terminalia ivorensis*. The organs of these plants indicated in the medicinal recipe preparations were used for phytochemical screening. The results are shown in Table 3. The table shows that saponins and alkaloids are present in all plant organs. Quinonic substances are present in the bark of *C. afer* and *R. heudelotii* and absent in the leaves of the other three plant species. The other chemical groups have variable presence from one plant to another.

Table 3 Results of phytochemical screening

Chemical groups		<i>C. afer</i> (stem bark)	<i>R. heudelotii</i> (root bark)	<i>K. Ivoriensis</i> (leaves)	<i>S. torvum</i> (leaves)	<i>T. ivoriensis</i> (leaves)
Sterols et polyterpenes		+	–	++	++	++
Polyphenols		–	+	+	++	+
Flavonoids		+	–	+	+	+
Tannins	Gallic	–	–	+	–	+
	Catechic	+	–	+	+	–
Quinone substances		+	+	–	–	–
Alcaloids	Dragendorff (D)	+	+	+	+	+
	Burchard (B)	+	+	++	++	++
Saponins		+	+	+	+	+

+ : presence of chemical group ++ : abundance of chemical group –: absence of chemical group

The absence of quinone substances in the leaves is a valid observation, as they are sometimes toxic to health [17]. Furthermore, their presence in the bark requires dose control in the administration of these phytomedicines. Furthermore, the presence of saponins and alkaloids in all plant organs could be the source of the medicinal properties of these plants, as their therapeutic roles are indicated in several studies [18].

4. Conclusion

The ethnomedicinal study of the plants of the sacred forest of Zadepleu made it possible to inventory 32 species used by the populations. The parts of these plants used in medicinal recipes are: leaves and leafy branches (55%), bark (24%), roots (17%), and fruits (4%). The leaves are the most frequently used organs (70%). The preparation techniques are: decoction (60%), kneading (25%), trituration (15%). The preferred method of administration of these phytomedicines is drinking (56%). The Citation Frequencies (FC) indicated five most used species: *Costus afer*, *Ricinodendron heudelotii*, *Khaya ivorensis*, *Solanum torvum* and *Terminalia ivorensis*. A phytochemical screening was carried out on the organs of these 5 plants. The results showed the presence of saponins and alkaloids in all the plant organs analyzed. The use of plants from the sacred forest of Zadepleu in local pharmacopoeia could have a scientific basis given the presence of these chemical groups. The sacred forest of Zadepleu therefore has undeniable importance for the local populations. It deserves to be always protected.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest about this study.

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