Inventory of plants used in the treatment of viral diseases, sold on markets in the district of Abidjan

Gbouhoury Eric-Kévin BOLOU 1,*, Bi Boli Francis TRA 1, Konan YAO 1, Julie José-Rita BOUAGNON 2, Casilde Jessica Sintes Ruth LIDJI 3, Constanse Désirée Ruth N'GUESSAN 3, Jean David N'GUESSAN 3, Guédé Noel ZIRIHI 4 and Allico Joseph DJAMAN 3

1 National Center of Floristic, UFR Biosciences, Felix HOUPOUET-BOIGNY University, Côte d'Ivoire.
2 Pasteur Institute of Côte d'Ivoire.
3 Laboratory of Biology and Health, UFR Biosciences, Felix HOUPOUET-BOIGNY University, Côte d'Ivoire.
4 Natural environment laboratory and biodiversity conservation, UFR Biosciences, Felix HOUPOUET-BOIGNY University, Côte d'Ivoire.

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Abstract

This survey, which took place in the midst of the Covid 19 global health crisis, was conducted on medicinal plants used in the traditional treatment of the most common viral diseases in Côte d'Ivoire. The aim was to inventory the plant species sold and collect ethnopharmacological data related to these plants.

Semi-structured interviews were conducted with herbalists in nine markets in the district of Abidjan. The information collected was processed using SPSS 17.0 computer and statistical software. This study revealed that shingles, yellow fever and chickenpox are the viral diseases for which there are more traditional remedies. A total of 61 species of antiviral medicinal plants distributed in 59 genera and 54 botanical families were identified. Fabaceae (14.75 %), Asteraceae (9.8 %), and Apocynaceae (9.8 %) are the most represented families. Six species are most commonly used in the treatment of viral diseases. They are, in decreasing order of frequency of use: Ocimum gratissimum, Citrus aurantiifolia, Spondias mombin, Allium sativum, Gymnanthemum amygdalinum, Kalanchoe crenata. The leaves are the most used parts, in the form of a decoction (73.84 %). This is consistent with the predominance of the beverage (39.62 %) as a form of use and the oral route of administration (42 %).

This study, which allowed the collection of ethnomedicinal data, is positioned as an orientation in the search for effective active ingredients against emerging ET re-emerging viral diseases.

Keywords: Plants; Viral Diseases; Antiviral; Herbalist; Côte d'Ivoire

1. Introduction

There are many viral diseases, ranging from the mildest to the most serious. They are often transmissible and can take the form of an epidemic. Among the best known are angina, the common cold, influenza, chicken pox, measles, hepatitis B, herpes, AIDS and more recently Covid-19. Some of these are real public health problems affecting many countries, both developed and developing. In 2019, 36 million people were living with HIV [1] and today, the whole world is fighting the Covid-19 pandemic which has already caused at least 6 million deaths [2]. Unfortunately, like AIDS and Covid-19, for many viral pathologies, there are still no official pharmaceutical specialities to cure them efficiently and a lower
cost. This is why the use of traditional medicine to combat these diseases is encouraged by the WHO [3]. But with deforestation, many plants are threatened and much local knowledge has disappeared. Therefore, for Betti [4, 5], it is important to carry out ethnobotanical studies to identify the local uses of plant species for health purposes. In Côte d’Ivoire, several ethnobotanical and ethnopharmacological studies have been conducted on medicinal species, their recipes as well as the forms of use for the realization of a pharmacopoeia. Thus, Ambé et al. [6] highlighted several anti-diarrheal plants while N’guessan et al. [7] and Wangny et al. [8] respectively characterized anti-malarial plants and plants used against hypertension. However, very little work has been done on antiviral plants. Hence the interest of this study, in the current global health context. While Vroh Bi [9] carried out a bibliographic review of plants used against the symptoms of Covid-19 in sub-Saharan Africa, our study on the other hand is focused on the antiviral plants used in Côte d’Ivoire. The general objective of this study is to contribute to the search for plant-based drugs against certain viral diseases. Specifically, it will identify, characterize and catalog some plants used in the treatment of viral diseases. To achieve this, we first conducted an ethnopharmacological survey on plants used against viral diseases and sold in the markets of three communes in the district of Abidjan. We then processed the data from this survey. This study, which is part of the valorization of natural substances, is the starting point for the identification of antiviral properties of certain tropical medicinal plants and the search for new antiviral active principles.

2. Material and methods

2.1. Study site

Our study took place in the central, northern and western parts of the autonomous district of Abidjan, the economic capital in the south of Côte d’Ivoire. The survey took place in markets in the communes of Adjamé, Abobo and Yopougon. These communes are adjacent to the Banco forest (Fig. 1) and are the primary sites for wholesale distribution of medicinal plants. In addition, these communes have the largest sales markets for medicinal plants.

![Figure 1 Study sites in the city of Abidjan](image)

2.2. Material

The material consists of all the medicinal plants used in the treatment of viral diseases and the classic technical material for collecting information. These include survey forms (see Appendix 1), newsprint, paper wrappers, paper tape, a camera and a dictaphone.
2.3. Data collection

In this study, the survey was conducted on medicinal plants used in the treatment of viral diseases and the different methods of use by herbalists for the treatment of these conditions. Data collection was conducted using the semi-structured interview technique [10; 11; 12; 13] and was conducted in a total of nine markets. Each interview was accompanied by the purchase of medicinal plants marketed and used for the treatment of viral diseases. These purchases constituted collections of specimens that were identified at the National Center of Floristics, University Félix HOUPOUET-BOIGNY. The ethnopharmacological survey was conducted with 32 herbalists. Individual interviews were conducted with the herbalists who were available and who agreed to answer the questions. During the interviews, the information collected concerned the profile of the herbalists (gender, age and experience), ethnobotanical and ethnopharmacological data such as local names of the species, the parts of plants used, the modes of preparation and use, the routes of administration and the dosage.

2.4. Data processing

The data collected during this survey was processed as follows: the tabulation of the survey forms followed by the statistical analysis of the results. Thus, the responses to the questionnaires were tabulated, coded, entered and processed using the EXCEL 2016 spreadsheet. These data were statistically processed using XLStat version 2014 software. The citation frequency (Fc) of each plant was determined by the following formula.

\[ Fc = \frac{Nc}{Nt} \times 100 \]

Where Nc is the number of citations for the plant under consideration and Nt is the total number of citations for all plants.

As for the statistical analysis of the data, the Chi-square (χ²) test was the only statistical test used in this study to compare the frequencies of use of the organs, modes of preparation, modes of administration, and routes of administration of the different plants used in viral conditions. These data were processed using XLStat software version 2014.5.03 (XLStat, 2014). When a difference exists between two or more frequencies at the 5% threshold, the Chi-square test is completed using the procedure of Marascuilo and Serlin [14]. Marascuilo’s procedure involves performing pairwise comparison tests for all pairs of proportions, which identifies the proportions responsible for the existence of linkage.

3. Results and discussion

The surveys included 32 herbalists, all of whom were female. Their ages varied between 18 and 55 years. Their number of years of experience in the commercialization of medicinal plants varies between 01 and 15 years.

3.1. Diseases treated

This survey focused on the treatment of 10 viral diseases which are shingles, yellow fever, chickenpox, influenza, colds, viral hepatitis, angina, mumps, measles and AIDS. Among these diseases, those most treated by the plants sold in the three municipalities are shingles, yellow fever and chickenpox with citation rates that vary between 18.28% and 21.51%. Mumps, measles and AIDS do not seem to be sufficiently treated with medicinal plants (Table 1).

Table 1 Citation frequencies for viral diseases

| Diseases         | Number of citations | Percentage (%) \(^1\) |
|------------------|---------------------|----------------------|
| shingles         | 20                  | 21.51\(^a\)          |
| yellow fever     | 17                  | 18.28\(^b\)         |
| chickenpox       | 17                  | 18.28\(^a\)         |
| flu              | 13                  | 13.98\(^ab\)        |
| common cold      | 12                  | 12.9\(^ab\)         |
| viral hepatitis  | 6                   | 6.45\(^ab\)         |
| angina           | 5                   | 5.38\(^ab\)         |
### Statistical parameters of the Chi-square test

|       |       |       |
|-------|-------|-------|
| mumps | 1     | 1.08b |
| measles | 1     | 1.08b |
| AIDS  | 1     | 1.08b |

1For each parameter, the percentages followed by the same letters are not significantly different; (α = 0.05). 2dl: degree of freedom; χ²: statistical value of the Chi-square test; P: Probability

### 3.2. Richness and composition of the plants surveyed

During this study, 61 species of medicinal plants used against viral diseases were identified by herbalists in the city of Abidjan. This shows the floristic richness of the plants sold in the markets visited. Moreover, according to Monteiro et al. [15], in general, the medicinal plants sold on the markets have an average of one hundred species. The 61 species of antiviral plants identified in this study are divided into 59 genera and 54 botanical families. The most represented families are Fabaceae (14.75%), Asteraceae (9.8%), and Apocynaceae (9.8%). These first two families are also recognized as such in the surveys of Guinnin et al. [16], who worked on antiviral plants. The species most known by traders for the treatment of viral conditions are in decreasing order of citation frequency: Ocimum gratissimum, Citrus lemon, Spondias mombin, Allium sativum, Gymnanthemum amygdalinum, Kalanchoe crenata (Table 2). None of these plants are among the threatened species of the Ivorian flora. Most of the plants identified in this study and the plants of the traditional pharmacopoeia in general, are woody plants, as evidenced by the previous work of several authors [17; 18; 19].

### 3.3. Characteristics of drugs and their uses in the treatment of viral diseases

#### 3.3.1. Parts used

Leaves are the most used parts in the preparation of herbal medicines against viral diseases, with a citation rate of 65.15%. All other plant forms or organs such as stem barks, fruits, roots, leafy twigs, whole plants and rhizomes, have statistically similar frequencies of use (Table 3). The predominance of leaves, in agreement with the work of Diatta et al. [18], Gueye et al. [20], Zerbo et al. [19] and Zirihi [21], who also showed that leaves are the most used plant organs in traditional medicine in the treatment of various ailments. This predominance is also explained by the richness of secondary metabolites in leaves. The leaf is the site of biosynthesis of these phytomolecules [22; 23; 24]. They are generally rich in terpenoids including some with antiviral potency, such as lupeol, betulinic acid and others [25; 26].

#### 3.3.2. The modes of preparation

This study revealed five modes of preparation of the medicinal recipes which are decoction, incineration, aqueous maceration, kneading and trituration. For the treatment of viral diseases, most of the plants used are prepared in the form of decoction. This method of preparation represents 73.84% (Table 4). Indeed, as water is the most used solvent, for an efficient extraction of thermoresistant active ingredients, decoction is the best indicated preparation. Moreover, decoction allows to destroy or cancel the toxicity of some compounds [6; 27] and to eliminate the microorganisms sheltered by the plant materials.
Table 2 Ethnobotanical characteristics of the plants surveyed

| SCIENTIFIC NAMES                     | FAMILIES   | SPECIMEN NUMBERS | USED PARTS | FREQUENCY OF CITATION (%) | VERNACULAR OR COMMON NAMES (LOCAL LANGUAGE) | TREATED DISEASES | PREPARATION METHODS | METHODS OF ADMINISTRATION | DOSAGE |
|--------------------------------------|------------|------------------|------------|---------------------------|---------------------------------------------|------------------|-----------------------|--------------------------------|--------|
| Acanthospermum hispidium DC          | Asteraceae | UCJ003383        | Leaves     | 0.45%                     | sourakanouéni (Malinké)                      | chicken pox      | decoction             | beverage                        | 2 times a day |
| Adenia lobata (Jacq.) Angl.          | Passifloraceae | UCJ014196     | Leaves     | 0.45%                     | arèman (Malinké)                            | shingles         | decoction             | bath and enema                   | 2 times a day |
| Aframomum melegueta K. Schum         | Zingiberaceae | UCJ017668      | Fruits     | 0.90%                     | kpahibè (bété) maniguette (french)           | angina           | kneading              | cutaneous application            | 1 time a day |
| Ageratum conizoides (L.) L.          | Asteraceae | UCJ003411        | Leafy branches | 1.36%                   | aboldó (Boublé), Roi des herbes (french)    | cold, flu        | trituration           | Nasal instillation               | 2 times a day |
| Allium sativum                       | Amaryllidaceae | Allium     | Fruits     | 8.63%                     | ail (french)                                | chicken pox, shingles | kneading, aqueous maceration | cutaneous application, enema, beverage | 1 time a day |
| Aloe buettneri A. Berger             | Xanthorrhoeaceae | UCJ011322    | Leaves     | 0.45%                     | aloès (french)                              | shingles         | kneading              | cutaneous application            | 2 times a day |
| Alstonia boonei De Wild.             | Apocynaceae | UCJ001553       | Stem barks | 2.72%                     | Emien (baoulé, agni)                        | chicken pox      | decoction             | beverage, bath                   | 2 times a day |
| Anchomanes difformis (Blume) Engl.   | Araceae    | UCJ002331       | Leaves     | 0.45%                     | dina tali (Yacouba), dé (Malinké), bédro - bédro (Bété) | flu              | decoction             | beverage                        | 2 times a day |
| Artemisia annua L.                   | Asteraceae | Artemisia       | Leaves     | 0.45%                     | Artemisia (french)                          | flu              | decoction             | beverage                        | 2 times a day |
| Azadirachta indica A. Juss.          | Meliaceae  | UCJ012262       | Leaves     | 0.45%                     | Nime (french)                               | flu, yellow fever | decoction             | beverage                        | 2 times a day |
| Bambusa vulgaris Schrad.             | Poaceae    | UCJ006786       | Leaves     | 0.45%                     | Bambou de chine (french)                     | yellow fever     | decoction             | beverage                        | 2 times a day |
| Piliostigma thonningii (Schum.) Milne-Redh. | Fabaceae | UCJ009483       | Leaves     | 0.45%                     | gnamanbou (malinké)                         | chicken pox      | decoction             | beverage, bath and enema         | 2 times a day |
| Scientific Name | Family       | Taxonomy Code | Part Used | Note | Treatment | Preparation | Place of Use | Frequency     |
|-----------------|--------------|---------------|-----------|------|-----------|-------------|--------------|---------------|
| Bersama abyssinica subsp. paulliniaoides (Planch.) Verdc. | Melianthaceae | UCJ012391 | Roots | 0.45% | lèglègbégbéhi (bété) | cold | aqueous maceration | Nasal instillation | 1 time a day |
| Guiletina bonduc Griseb. | Fabaceae | UCJ009109 | Leaves | 0.45% | awalé (haoulé) | chicken pox | decoction | beverage, bath | 2 times a day |
| Calotropis procera (Aiton) Dryet. | Apocynaceae | UCJ002509 | Leaves | 0.45% | toupatou d’Ivoire) | shingles | decoction | beverage | 2 times a day |
| Carica papaya L. | Caricaceae | UCJ002676 | Leaves | 0.45% | papayebrou (malinké) | chicken pox | decoction | beverage | 2 times a day |
| Citrus aurantiifolia (Christm.) Swingle | Rutaceae | CSRS006370 | Leaves | 11.36% | citron (french) | chicken pox, hepatitis, shingles, angina, rougeole | decoction | beverage, cutaneous application | 2 times a day |
| Cymbopogon citratus (DC.) Stapf | Poaceae | UCJ007004 | Leaves | 0.90% | Citronnelle (french) | cold, flu, yellow fever | decoction | beverage | 2 times a day |
| Elaeis guineensis | Areceae | UCJ014116 | Fruits | 0.45% | Ayé (Agni), goholo (bété) | shingles | incineration | cutaneous application | 2 times a day |
| Eucalyptus platypylla F.Muell. | Myrtaceae | Eucaluptus | Leaves | 0.90% | Djoum (Malinké) | Yellow fever | decoction | beverage, bath | 2 times a day |
| Funtumia elastica (Preuss) Stapf | Apocynaceae | UCJ002015 | Stem barks | 0.45% | gnahsou (bété) | Yellow fever | decoction | beverage | 2 times a day |
| Gliricidia sepium (Jacq.) Walp. | Fabaceae | UCJ010419 | Leaves | 0.45% | gliricidia | flu | decoction | beverage | 2 times a day |
| Gossypium hirsutum L. | Malvaceae | UCJ011821 | Leaves | 1.36% | conibou (malinké), feuille de coton (cote d’Ivoire) | cold, chicken pox, yellow fever | decoction | beverage, bath | 2 times a day |
| Holarrhena floribunda (G.Don) T.Duret & Schinz | Apocynaceae | UCJ002020 | Stem barks | 0.45% | kouna sana (Malinké), torotoro (Gouro de Sinfra), sagéï (Bété), sébé (Baoulé) | shingles | kneading | cutaneous application | 1 time a day |
| **Hoslundia opposita Vahl** | Lamiales | UCJ008830 | Leaves | 0.45% | anomalé (Agni, Baoulé), zakrolebakro (Bété) | cold, flu | triturating/decoction | Nasal instillation/beverage | 2 times a day |
|-----------------------------|----------|----------|--------|-------|-----------------------------------------------|-----------|-------------------------|-----------------------------|-----------------|
| **Jatropha gossypifolia L.** | Euphorbiaceae | UCJ006119 | Leaves | 0.45% | aplopló (baoulé) | mumps | kneading | cutaneous application | 2 times a day |
| **Kalanchoe crenata (Etrews) Haw.** | Crassulaceae | UCJ004319 | Leaves | 5.45% | akpolelgí (baoulé), feuille lourde lourde | cold, flu | triturating | Nasal instillation | 2 times a day |
| **Khaya senegalensis (Desv.) A.Juss.** | Meliaceae | UCJ012302 | Stem barks | 2.27% | djalà (malinke) | chickenpox, shingles | decoction | bath, beverage and enema | 2 times a day |
| **Lawsonia inermis L.** | Lythraceae | UCJ011747 | Leaves | 0.45% | djabibrò (malinké) | yellow fever | decoction | bath, beverage and enema | 2 times a day |
| **Mangifera indica L.** | Anarcardiaceae | UCJ000983 | Leaves/Stem barks | 0.45% | manguier male | yellow fever, shingles | decoction | bath, beverage and enema | 2 times a day |
| **Mikania cordata (Burm.f.) BLRob.** | Asteraceae | UCJ003775 | Leafy branches | 1.81% | kpitakpita azalai (agni) | cold, yellow fever, chickenpox, shingles | decoction | bath, beverage, nasal instillation and enema | 2 times a day |
| **Momordica charantia L.** | Cucurbitaceae | UCJ004434 | Leaves | 0.45% | crékété (malinké) | hepatitis | decoction | beverage, enema | 2 times a day |
| **Sarcocephalus lattifolius (Sm.) EABruce** | Rubiaceae | UCJ015407 | Leaves/Root barks/Root | 2.72% | bât (malinké), tété (baoulé) | chickenpox, hepatitis | decoction | bath, beverage and enema | 2 times a day |
| **Newbouldia laevis (P.Beauv.) Semble.** | Bignoniaceae | UCJ001965 | Stem barks | 0.45% | hysope (French) | shingles | decoction | bath, enema | 2 times a day |
| **Nicotiana tabacum L.** | Solanaceae | UCJ016861 | Leaves | 0.45% | asragnan (agni) | shingles | kneading | cutaneous application | 2 times a day |
| Plant Name                                      | Family            | Part Used | Standardization | Uses/Preparation                                                                 | Routes of Administration | Dosage |
|------------------------------------------------|-------------------|-----------|-----------------|---------------------------------------------------------------------------------|---------------------------|--------|
| Ocimum americanum L.                           | Lamiaceae         | Leaves   | 2.27%           | cold, yellow fever                                                               | decotion, trituration    | 2 times a day |
| Ocimum gratissimum L.                          | Lamiaceae         | Leaves   | 14.54%          | amangniné (baoule)                                                              | cold, flu, angina    | 2 times a day |
| Olax subscorpioides Oliv.                      | Olaceae           | Leaves   | 0.90%           | akindjé (agni), wanwan-yiri (gouro)                                           | decoction               | 2 times a day |
| Crytoplepis calophylla (Baill.) L. [oubert & Bruyns] | Apocynaceae       | Leaves   | 0.45%           | sroboüé (baoulé)                                                               | shingles, kneading      | 2 times a day |
| Paullinia pinnata L.                            | Sapindaceae       | Leaves   | 0.90%           | trondi (baoulé), iridjanbrou (malinké)                                         | decoction, beverage, bath | 2 times a day |
| Phyllanthus amarus Schumach. & Thonn.          | Phyllanthaceae     | Whole plant | 0.45%         | dëmanço (malinké), mille-maladies (french)                                    | cold, decoction, beverage | 2 times a day |
| Pseudarthria hookeri Wight & Arn.              | Fabaceae          | Leaves/ Roots | 0.45%       | tilibala (malinké)                                                            | angina, decoction, steam suction | 2 times a day |
| Pterocarpus erinaceus Poir.                    | Fabaceae          | Stems    | 0.45%           | gbin (malinké)                                                                | shingles, decoction, bath, enema | 2 times a day |
| Ricinus communis L.                            | Euphorbiaceae     | Leaves   | 0.45%           | solokofala (malinké)                                                          | shingles, decoction, beverage, bath, enema | 2 times a day |
| Rauvolfia vomitoria Azel.                      | Apocynaceae       | Leaves   | 0.45%           | gnawi (baoulé)                                                                | chicken pox, decoction, bath | 2 times a day |
| Flueggea virosa (Roxb. ex Willd.) Royle        | Phyllanthaceae     | Leaves   | 0.45%           | mokrodoma (Malinké)                                                           | cold, trituration, nasal instillation | 1 time a day |
| Senna alata (L.) Roxb.                         | Fabaceae          | Leaves   | 0.90%           | djorouba brou (malinké)                                                        | flu, decoction, beverage | 2 times a day |
| Senna occidentalis (L.) Link                   | Fabaceae          | Leaves   | 0.90%           | kinkéléba (malinké)                                                            | yellow fever, decoction, beverage, bath | 2 times a day |
| Sida acuta Burm.f.                             | Malvaceae         | Leafy branches | 0.45%      | kélékolaka (baoulé), barillé (malinké)                                         | aids, aqueous maceration, enema | 1 time a day |
| Scientific Name | Family         | Accession | Part of Plant | Percentage | Common Names | Diseases                  | Treatment               | Usage                                                                 | Frequency       |
|----------------|----------------|-----------|---------------|------------|--------------|---------------------------|-------------------------|----------------------------------------------------------------------|-----------------|
| Spondias mombin L. | Anarcardiaceae | UCJ001020 | Leaves        | 10.45%     | tromagna (baoule), mirabelle (french), mosambrou (malinké) | chicken pox, shingles, hepatitis | decoction              | beverage, bath, cutaneous application, enema                          | 2 times a day   |
| Stylosanthes erecta | Fabaceae      | UCJ011041 | Leaves        | 0.45%      | dofaga (malinké) | yellow fever               | decoction              | beverage                                                            | 2 times a day   |
| Tamarindus indica L. | Fabaceae      | UCJ009522 | Leaves        | 0.45%      | tomi (malinké) | chicken pox               | decoction              | beverage                                                            | 2 times a day   |
| Tectona gretis L. | Lamiaceae      | UCJ017491 | Leaves        | 0.45%      | téki (gouro) | yellow fever, flu         | decoction              | beverage                                                            | 2 times a day   |
| Terminalia glaucescens Planch. ex Benth. | Combretaceae  | UCJ003137 | Leaves        | 0.45%      | wolo (malinké) | flu, yellow fever          | decoction              | beverage                                                            | 2 times a day   |
| Tithonia diversifolia (Hemsl.) A.Gray | Asteraceae    | UCJ003863 | Leaves        | 2.72%      | atindé (baoulé), marguerite (french) | chicken pox, shingles, yellow fever | decoction              | beverage, bath, enema and cutaneous application                      | 2 times a day   |
| Trema orientalis (L.) Blume | Cannabaceae  | UCJ017317 | Leaves        | 0.45%      | sodomkola (malinké) | Yellow fever               | decoction              | beverage, bath, enema and cutaneous application                      | 2 times a day   |
| Gymnanthemum amygdalinum (Delile ) Sch.Bip. ex Walp. | Asteraceae    | UCJ003893 | Leaves        | 6.36%      | cohsafnan (malinké), abowi (baoulé) | chicken pox, shingles | decoction              | beverage, bath, enema and cutaneous application                      | 2 times a day   |
| Vitellaria paradoxa C.F.Gaertn | Sapotaceae    | UCJ016458 | Fruits        | 0.45%      | beurre de karité (french) | shingles | decoction | cutaneous application                                                | 2 times a day   |
| Xylopia aethiopica (Dunal) A.Rich. | Annonaceae    | UCJ001462 | Fruits        | 0.45%      | loro (bété), fondé (Abé), efomou (Agni) | flu | decoction | beverage                                                              | 2 times a day   |
| Zanthoxylum zanthoxyloides (Lam.) Zepern. & Timler | Rutaceae      | UCJ016155 | Stem barks/ root barks | 1.36%     | kédjé (baoulé) | shingles, hepatitis, angina | decoction | cutaneous application, beverage                                      | 2 times a day   |
| Zingiber officinale Roscoe | Zingiberaceae | Zingiber  | Rhizomes      | 0.90%      | gnamankou (malinké), gingembre (french) | cold | decoction | beverage                                                              | 2 times a day   |
### Table 3 Frequency of use of different plant organs

| Parts used   | Number of citation | Percentage (%) 1 |
|--------------|--------------------|------------------|
| Leaves       | 43                 | 65.15 a          |
| Stem Barks   | 9                  | 13.64 b          |
| Fruits       | 5                  | 7.56 b           |
| Roots        | 4                  | 6.06 b           |
| Leafy branches | 3              | 4.55 b           |
| Whole plant  | 1                  | 1.52 b           |
| Rhizomes     | 1                  | 1.52 b           |
| Total        | 66                 | 100              |

| Statistical parameters of the Chi-square test2 |
|-----------------------------------------------|
| dl                                           | 6 |
| \( \chi^2 \)                                | 168.247 |
| \( P \)                                    | < 0.001 |

1 For each parameter, the percentages followed by the same letters are not significantly different; \( \alpha = 0.05 \). 2dl: degree of freedom; \( \chi^2 \): statistical value of the Chi-square test; \( P \): Probability

### Table 4 Methods of preparation of medicinal plants

| Method of preparation   | Number of citation | Percentage (%) 1 |
|-------------------------|--------------------|------------------|
| decoction               | 48                 | 73.84 a          |
| incineration            | 1                  | 1.54 b           |
| Aqueous maceration      | 3                  | 4.62 b           |
| kneading                | 7                  | 10.77 b          |
| trituration             | 6                  | 9.23 b           |

| Statistical parameters of the Chi-square test2 |
|-----------------------------------------------|
| dl                                           | 5 |
| \( \chi^2 \)                                | 179.68 |
| \( P \)                                    | < 0.001 |

1 For each parameter, the percentages followed by the same letters are not significantly different; \( \alpha = 0.05 \). 2dl: degree of freedom; \( \chi^2 \): statistical value of the Chi-square test; \( P \): Probability

### 3.3.3. The ways and modes of administration

The medicinal preparations derived from the plants surveyed are administered by four routes, the oral route, the cutaneous application, the anal route and the nasal route. The oral and cutaneous routes are the most favoured with respective rates of 42% and 32% (Fig. 2).

Indeed, the ways of administration are related to the modes of administration. In the traditional treatment of viral diseases, this study reveals that most of the plants listed are used in the form of beverage (39.62%), then sometimes by oral aspiration of steam hence the predominance of the oral or buccal route as shown in the work of Guinnin et al. [16]. Then the preparations are administered in the form of bath or by local application to borrow the cutaneous way. Some are administered in the form of enema by anal route while others are used by nasal instillation. Besides the preparations in the form of beverages, which are the most frequent practices in the administration of phytoremedias against viral diseases, the intake of these medicines in the form of baths, enema and by local application, are modes of administration that appear with similar frequency (Table 5). The intake of antiviral medicinal recipes in the form of beverage then oral
and cutaneous applications are privileged here because most of the viral diseases targeted in this study, are systemic diseases, which alter the internal organs and which sometimes, have cutaneous applications manifestations (yellow fever, chicken pox, flu, measles etc). Thus, to reach their targets, bioactive phytocompounds must reach the bloodstream through the digestive system.

![Figure 2: Comparison of the routes of administration of traditional medicines in the treatment of viral diseases](image)

**Table 5** Methods of administration of medicinal preparations

| Methods of administration          | Number of citation | Percentage (%) |
|-----------------------------------|--------------------|----------------|
| Beverage                          | 42                 | 39.62<sup>a</sup> |
| Bath                              | 22                 | 20.76<sup>b</sup>  |
| Enema                             | 18                 | 16.98<sup>b</sup>  |
| Cutaneous application             | 15                 | 14.15<sup>b</sup>  |
| Nasal instillation                | 8                  | 7.55<sup>bc</sup>  |
| Steam suction                     | 1                  | 0.94<sup>c</sup>   |

**Statistical parameters of the Chi-square test**

| dl     | 5 |
|--------|---|
| $\chi^2$ | 78.83 |
| $P$     | < 0.001 |

<sup>1</sup>For each parameter, the percentages followed by the same letters are not significantly different; (α = 0.05). <sup>2</sup>dl: degree of freedom; $\chi^2$: statistical value of the Chi-square test; P: Probability

### 4. Conclusion

The present study allowed us to observe the diversity of medicinal plants used against viral diseases and sold on markets in the district of Abidjan in Côte d’Ivoire. *Ocimum gratissimum* appeared as the most used plant. Leaves are the most used organs for medicinal preparations which are mostly in the form of orally administered decoctate. This study highlights the essential role of traditional medicine in the treatment of viral diseases in Côte d’Ivoire. It suggests very important perspectives that should eventually allow the isolation and identification of new antiviral active principles.

### Compliance with ethical standards

**Disclosure of conflict of interest**

The authors declare that there are no conflicts of interest related to this manuscript.
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