INTRODUCTION

At the end of an ethnobotanical survey conducted in 1991 in the area of Issia (Cote d’Ivoire) several medicinal plants were collected and identified by our research team. These plants are commonly used in traditional circles by the healers for their curative virtues. A large number of plants among the cataloged species are granted anti-infectious properties [1]. The in vitro anti-microbial properties of some plants have already been assessed by some members of our research team. This study was initiated to verify the anti-microbial virtues which some plants are granted in order to continue the studies initiated by our team. In this report, we summarize the results obtained after some in vitro tests with aqueous and hydroethanolic extracts from each plant against Candida albicans one of the most pathogenic fungi species to human.

MATERIALS AND METHODS

Plant Material

Different parts of plants were collected in the area of Issia (Cote d’Ivoire) during the ethnobotanical investigations. The
collected parts were the steam barks of the trees species and the whole aerial parts for the herbaceous species. The studied plants species are the following:

- **Ceiba pentandra** (L.) Gaertn. (Harvested in Soubakaniédougou January 1, 1965, L. Aké-Assi Number 7601);
- **Entandrophragma angolense** (Welw.) C.D.C. (Côte d’Ivoire: Yakassé August 22, 1978, L. Aké-Assi Number 14198);
- **Entandrophragma cylindricum** (Sprague) (Mopri Forest, December 17, 1965, L. Aké-Assi Number 8348);
- **Guarea cedrata** (A. Chev.) Polleg. (Côte d’Ivoire: National Parc of Azagny, January 22, 1986 L. Aké-Assi Number 17242);
- **Hunteria ebenea** Pichon (Abouabou forest, November 15, 1948, Mangenot and Aké-Assi Number 748);
- **Khaya ivorensis** A. Chev. (Côte d’Ivoire: Floristic National Center, Abidjan February 20, 1991, E. Aké-Assi Number 77);
- **Milicia excelsa** (Welw.) C.C. Berg (Agbo forest, September 23, 1957, Adjanohoun Number 1911B);
- **Mitracarpus villosus** (SW).DC. (Biankouna, August 11, 1975, L. Aké-Assi Number 12926);
- **Nesogordonia papaverifera** (A. Chev.) Cap. (Gabia, November 30, 1966, L. Aké-Assi Number 9320);
- **Physalis angulata** L. (Dabou, January 18, 1964, L. Aké Assi Number 7503);
- **Solenomostemon monostachyus** (P. Beauv.) Briq. (Man, November 15, 1953, L. Aké-Assi Number 2815);
- **Terminalia catappa** Linn. (Côte d’Ivoire: Azuretti, July 15, 1964, G. Cremers Number 266);
- **Terminalia ivorensis** A. Chev (Adiodopouné, May 17, 1966, L. Aké-Assi Number 8655);
- **Terminalia mantaly** H. Perrier (Floristic National Center of Cocody University, Abidjan, May 23, 1995, E. Aké-Assi Number 217);
- **Terminalia superba** Engl. & Diels (Tonkoui Mountain February 26, 1969, L. Aké-Assi Number 10477);

In the first step of the study some samples of all the plants species were identified and taxonomically authenticated by professor Aké-Assi at the Herbarium of the floristic national center of the Felix Houphouët-Boigny University (Abidjan, Côte d’Ivoire). In the second step, some great quantities of plant parts of each species were collected separately. The parts were carefully checked to take out all undesired specimen parts. The parts were then cut into small fragments and carefully air-dried for 2 weeks at ambient temperature in the laboratory, under continuous ventilation, away from sunlight and dust. After that step all, the vegetal pieces were crushed to a fine powder with an electrical grinder. Finally, the different types of powder were hermetically sealed in polyethylene bags and stored away from light and moisture until the time of extraction.

**Extraction**

Two sorts of extracts (aqueous and hydroethanolic) were prepared from the powder of each species. For the aqueous extract, 100 g of each type of powder were extracted in a solvent kept with 1 L of distilled water by homogenization in a blender. After six cycles of homogenization, the homogenates obtained were first wrung out in a fabric square and then filtered twice successively with absorbent cotton and once with Whatman 3 mm filter paper. The resulting filtrates were concentrated under vacuum using a Buchi rotary evaporator at 60°C [2]. Dark powder obtained is the aqueous crude extract. Hydroethanolic extracts were prepared following the same process by using a mixture of solvent ethanol 70% and water 30%.

**Microorganism Studied**

The tested fungi consist of a *C. albicans* (n 896/AB of 10.01.2000) clinical strain. It was both clinical isolate as well as authenticated and identified strain. This strain was provided by the Laboratory of Mycology of the Medical Sciences, Faculty of the Felix Houphouët-Boigny University (Abidjan Côte d’Ivoire).

*C. albicans* is an opportunistic fungus. It is a human normal commensal, and it belongs to the normal flora, but it becomes pathogenic when the immune system fails. It causes most of 83% of yeast infections [3,4]. The generalized infection caused by this fungus in individuals severely immuno-compromised often leads to death [5-9].

**Anti-microbial Test**

The anti-fungal activities were assessed by determining anti-fungal parameters values which are minimal fungicidal concentration (MFC); concentration that inhibits 99.99% of growth in the experimental tube compared with the growth control tube and concentration for 50% of inhibition (IC50); graphically determined around each assay. For each extract, six replicate trials were conducted against *C. albicans* and ketoconazole was used as standards for anti-fungal assay. Ketoconazole was selected because it is an anti-fungal molecule usually prescribed to patients in the treatment of mycosis.

The anti-fungal tests were carried out on culture medium Sabouraud (Biomerieux, 51078 Ref: 777666501). The incorporation of plant extracts into the agar was made using the agar slanted double dilution method [2,10-12]. After this, all 10 tubes of each series were sterilized in an autoclave at 121°C for 15 min and then inclined with a small base at room temperature to allow their cooling and solidification of the agar. Both aqueous and hydroethanolic extracts were tested separately.

Fungal germ culture on slanted agar previously prepared was made by sowing 1000 cells of *C. albicans* [11]. These cultures were incubated at 30°C for 48 h. At the end of the incubation time, colonies were counted out by direct counting with a colony counter pen (Ceinceware, number 23382). The growth in the 10 experimental tubes was expressed as survival percentage, calculated, compared to 100% of growth in the growth control tube. The formula to calculate this is shown below. For the test tubes, concentrations of plant extracts ranged from 1600 to 0.024375 mg/mL with a ½ reason geometrical connection.

The processing of these data permitted to calculate the MFC values. It also made it possible to plot the curves of...
activity of the extracts and the graphically determination of the IC50 values.

Formula to calculate the survival percentage:
\[ S = \frac{n}{N} \times 100 \]

S: Survival (%)
\( n \): Number of colony in one experimental tube
\( N \): Number of colony in the growth control tube.

Activity Classification Scale

The anti-fungal activities of the plant extracts were classified into the category following the scale below. The activity scale is divided into five levels on the basis of the MFC values.

| Activity          | Values                        |
|-------------------|-------------------------------|
| Very low activity | MFC values > 50 mg/mL         |
| Low activity      | MFC value = 50 mg/mL          |
| Average activity  | 50 mg/mL > MFC values ≥ 6.25 mg/mL |
| High activity     | 6.25 mg/mL > MFC values ≥ 0.780 mg/mL |
| Very high activity| 0.780 mg/mL > MFC values ≥ 0.001526 mg/mL |

RESULTS

The results were summarized in the form of curves of sensitivity and a table. The curves illustrate the evolution of the survival of \textit{C. albicans} depending on the variation of the concentrations of the extracts [Figures 1 and 2]. In general, all sensitivity curves showed a progressively decreasing pace with slopes that are stronger or not as strong according to the extracts. The curves whose slopes are strong illustrate high anti-fungal potency and those that have a weak slope reveal low anti-fungal potency. They intersect the horizontal axis at different levels according to the extracts. The slopes of the curves of the extracts from the \textit{Terminalia} species are the strongest. While the weakest slopes are observed with curve of extracts from \textit{G. cedrata} (BOSS) and \textit{E. cylindricum} (ECYL) [Figures 1 and 2]. The extracts from the other species have curves whose slopes are average. The decreasing shape of the activity curves shows that the 30 extracts acted according to a relation amount-effect.

Table 1 contains all the values of the anti-fungal parameters (MFC and the IC50). All the extracts tested were active against \textit{C. albicans}. The highest MFC values were produced by \textit{G. cedrata}, while the lowest ones were produced by \textit{T. superba}. All the hydroethanolic extracts from the four \textit{Terminalia} species produced MFC values that are lower than the MFC value of ketoconazole.

In addition to the four \textit{Terminalia} species, \textit{E. angolense} (ETAN), \textit{H. eburnea} (HUNT), \textit{M. excelsa} (EMI) and \textit{M. villosus} (MVS) are among those whose hydroethanolic extracts generated MFC values that are lowest than 50 mg/mL.

DISCUSSION

Analysis of the whole results shows that \textit{C. albicans} are sensitive to all the extracts tested. The extracts were all capable of inhibiting the \textit{in vitro} growth of the fungal germs. However, the levels of these anti-fungal activities are variable from one extract to another. As a matter of fact, the analysis of MFC values [Table 1] reveals that while some extracts resulted in very low MFC values, demonstrating their high efficiency, conversely extracts from some other species generated very high values of MFC revealing that they are not very efficient inhibiting the \textit{C. albicans} \textit{in vitro} growth. Among them the aqueous extract BOSS-XAq from \textit{G. cedrata} (MFC = 1600 mg/mL) possesses the weakest anti-candidosic activity. On the other hand, the hydroethanolic extract TEKAM4-X0 from \textit{T. superba}...
On the basis of the classification scale of the levels of the activities, the analysis of the data shows that among the aqueous extracts, nine plant species produced extracts whose MFC values range from 100 mg/mL to 1600 mg/mL. This led to classify them as plants whose extracts possess some very low levels of anti-fungal activities. These species are the following: C. pentandra, E. cylindricum, K. ivorensis, G. cedrata, M. excelsa, M. villosus, N. papaverifera, P. angulata, S. monostachyus. For this reason, these species are not recommended to treat anti-fungal infections in traditional circles. Unless an extraction method permitting a better concentration of their active principles as well as the improvement of their anti-fungal activities was applied.

The results also show that the aqueous extracts from E. angolense and H. eburnea have an MFC value of 50 mg/mL so they have a low activity level (Table 1 and anti-fungal activity classification scale). In addition, the aqueous extract TEKAM4-XAq from T. catappa inhibited the growth of C. albicans with a MFC value of 0.780 mg/mL. According to the anti-fungal activity classification scale, its anti-candidosic activity is classified as a high level of activity. Finally, the other three Terminalia species generated extracts whose MFC value are respectively 0.39 mg/mL for T. ivorensis and T. mantaly, 0.195 mg/mL for T. superba. This led to catalogue them in the category of those that have a very high level of anti-fungal activity (Table 1 and activity classification scale).

Otherwise, the comparison with previous works shows that the aqueous extract they got from T. mantaly was four times more active on C. albicans [13] than the same kind of extract we tested in this study. The MFC value obtained in their study was 0.0975 mg/mL for the aqueous extracts TEKAM1-XAq, while the MFC value is 0.390 mg/mL in this present study for the same type of extract. On the other hand, the comparison with works on T. superba [14] reveals that TEKAM1-XAq (MFC = 0.195 mg/mL) is two times more active than the (CMF = 0.0975 mg/mL) exhibited the strongest anti-candidosic activity [Table 1].
aqueous extract (MFC = 0.390 mg/mL) from *T. superba* tested by these authors. These differences of performance of these extracts could be explained by the fact that we did not collect the barks in the same area, and we did not test the extracts on the same *C. albicans* strain. The trees from which they collected the barks could contain low concentrations of active principles. And each fungal strain has its own sensitivity to anti-fungal drugs.

Meanwhile, the results from this study are in accordance with previous reports on the genus *Terminalia*, i.e. the works on *T. ivorensis* [15] and on *T. catappa* [16]. Because we obtained the same anti-fungal parameters values (MFC = 0.390 mg/mL and IC\textsubscript{50} = 0.054 mg/mL for *T. ivorensis* and MFC = 0.780 mg/mL and IC\textsubscript{50} = 0.523 mg/mL for *T. catappa*).

On the other hand, on the basis of MFC values, the comparison of the anti-fungal activities of all aqueous extracts shows that the aqueous extract from *T. superba* TEKAM\textsubscript{1}-X\textsubscript{aq} (CMF = 0.195 mg/mL) is the most active of all. As a matter of fact, the MFC value ratios reveal that TEKAM\textsubscript{1}-X\textsubscript{aq} is respectively two times more active than TEKAM\textsubscript{2}-X\textsubscript{aq} (from *T. mantaly*) and TEKAM\textsubscript{4}-X\textsubscript{aq} (from *T. chebula*), it is also four times more active than TEKAM\textsubscript{3}-X\textsubscript{aq} (from *T. superba*). As a matter of fact, the MFC values range from 0.195 mg/mL to 0.0975 mg/mL [Table 1]. Among them, the hydroethanolic extract (MFC = 0.390 mg/mL) from *T. excelsa* and BOSS-X\textsubscript{aq} (from *T. superba*) is respectively four times more active than TEKAM\textsubscript{1}-X\textsubscript{aq} and TEKAM\textsubscript{2}-X\textsubscript{aq}.

For the hydroethanolic extracts, the comparison of their performances on the basis of the MFC values highlights that for this kind of extracts, the four *Terminalia* species once more resulted in the lowest value of MFC [Table 1]. As a matter of fact, their MFC values range from 0.195 mg/mL to 0.0975 mg/mL [Table 1]. Among them, the hydroethanolic extract TEKAM\textsubscript{1}-X\textsubscript{aq} of *T. superba* possesses the lowest value of MFC (0.0975 mg/mL) meaning the strongest anti-candidosis activity. For the hydroethanolic extracts, the extracts from *G. cedrata* generated the lowest MFC and IC\textsubscript{50} values against *C. albicans*. And particularly extracts from *T. superba* exhibited the best performances of all.

This strong anti-microbial potency of *T. superba* was also demonstrated by works on its methanolic extract which showed a broad spectrum of both anti-fungal and anti-bacterial activities [17]. This methanolic extract inhibited the *in vitro* growth of several strains of bacteria (*Mycobacterium smegmatis*, *Mycobacterium tuberculosis*, *Staphylococcus aureus*, *Escherichia coli*, *Shigella dysenteriae*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Citrobacter freundii*) and fungi (*C. albicans*, *Candida glabrata*, *Mycosporum audouinii*, *Trichophyton rubrum*) [17].

Finally, the comparison of the performances of all extracts tested with that of ketoconazole, reveals that this reference anti-fungal drug is more active than most of extracts tested excepted few extracts from *Terminalia* species. As a matter of fact, KETO is 256 times more active than MONOS-X\textsubscript{aq}, PHYS-X\textsubscript{aq}, and ACAJB-X\textsubscript{aq}; 128 times more active than CEIBA-X\textsubscript{aq} and KOTIB-X\textsubscript{aq}; 64 times more active than HUNT-X\textsubscript{aq} and EMI-X\textsubscript{aq}; 32 times more active than ETAN-X\textsubscript{aq}; 16 times more active than MVX-X\textsubscript{aq}. Ketoconazole is also twice more active than TEKAM\textsubscript{1}-X\textsubscript{aq}. On the other hand, KETO produced the same MFC value (0.390 mg/mL) as TEKAM\textsubscript{1}-X\textsubscript{aq} and TEKAM\textsubscript{2}-X\textsubscript{aq}. However, on the basis of their IC\textsubscript{50} values, the comparison shows that KETO is respectively twice and three times more active than TEKAM\textsubscript{1}-X\textsubscript{aq} and TEKAM\textsubscript{2}-X\textsubscript{aq}.

However, compared with TEKAM\textsubscript{1}-X\textsubscript{aq}, TEKAM\textsubscript{2}-X\textsubscript{aq}, TEKAM\textsubscript{3}-X\textsubscript{aq}, and TEKAM\textsubscript{4}-X\textsubscript{aq} on the basis of their MFC values, KETO is respectively two times less active than these extracts. Finally, on the same basis of this comparison, TEKAM\textsubscript{1}-X\textsubscript{aq} (MFC = 0.0975 mg/mL), is clearly four times more active than ketoconazole [Table 1].

On the whole, the obtained data from this study highlighted the significant anti-fungal potency of plants of *Terminalia* genus. Otherwise, several investigations on plants of the genus *Terminalia* have already been conducted by some research teams. And many results of these previous reports share the results from the present study concerning their anti-microbial activities. Indeed, these works also confirmed the strong anti-microbial activities of extracts from a number of *Terminalia* species such as *T. catappa* [16,18,19], *T. chebula* [20], *T. glaucescens* [21], *T. ivorensis* [15,22-24], *T. macroptera* [25], *T. sericea* [26,27], and *T. superba* [14,17,28].
In addition, *M. villosus* was also reported for its broad spectrum of anti-fungal activities on *C. albicans*, *C. glabrata*, *C. tropicalis* and *A. fumigatus*, *A. flavus*, *C. neoformans*, *T. rubrum* and *T. mentagrophytes* [29-32]. The comparison reveals that on *C. albicans*, the *M. villosus* extracts [30] produced the same MFC values as the present report. However, on the basis of their IC_{50} values, they are two times less active than extracts from this study.

With other plant species, the comparison shows that TEKAM_{X_{aq}} and TEKAM_{X_{HE}} of *T. superba* are respectively 256 times and 125 times more active than aqueous extract and hydroethanolic extract from *Microglossa pyrifolia* tested on *C. albicans* [2].

Moreover, the comparison of the whole data shows that for all plant species, hydroethanolic extracts are more active than the aqueous ones. As a matter of fact, for each case, hydroethanolic extracts produced MFC values that are 2-16 times lower than the MFC values of their aqueous equivalents [Table 1] if one establishes a comparison between extracts from the same plant species. This shows that for all plant species, hydro-ethanolic extracts concentrate a greater proportion of active principles than their aqueous equivalents. This assertion is similar to former investigation reports [2,13,15,16,29-31,33]. Indeed, the results of these previous investigations revealed that all the hydro-ethanolic extracts tested were 2-16 times more active than the equivalent aqueous extracts.

So we can deduce that between the two solvents used for extraction, the mixture ethanol-distilled water (70/30; v/v) is the solvent that permits the activity optimization and concentrates better the active principles from the different plant species. The active principles of all the plant species studied are more soluble in the mixture ethanol-distilled water (70/30; v/v). Considered under the chemical aspect, hydro-ethanolic extracts contain active principles that are of lipid nature and also polar molecules containing one or many oxygen atoms [2,34].

In addition, the active principles could be groups constituted by molecules of small sizes and average sizes (terpenoids, polyphenols, quinons, alkaloids, etc.) containing very low proportions of vegetal oil and chlorophyll [2,33]. Even if water can extract all type of molecules, water extracts contain a great content of macromolecules (polysaccharids, proteins and glycoproteins). They also contain a few species of polar lipids of small size, whose structures are simples. This high proportion of polysaccharids, glycoproteins and proteins could explain why aqueous extracts are always less active.

Alternatively as regards this aspect, the analysis of the antifungal parameter values of Table 1 shows that among the aqueous extracts, only four plant species (*T. catappa*, *T. ivoreensis*, *T. mantaly*, *T. superba*) gave extracts exhibiting a high anti-fungal activity level. But for the hydro-ethanolic extracts, eight plant species (*E. angolense*, *H. eburnea*, *M. excelsa*, *M. villosus*, *T. catappa*, *T. ivoreensis*, *T. mantaly*, *T. superba*) gave satisfactory anti-fungal activities.

Furthermore, many authors explained that most of the plants synthesize various secondary metabolites which are useful for their normal biology and to fight pathogenic microorganisms (virus, bacteria, fungi and various parasites) attacks [35-37]. These anti-microbial secondary metabolites are found melted among diverse substances and compounds extracted from plants. This would explain why the extracts from most of these plants have anti-fungal activities. The variability of their efficiency would be not only connected to various secondary metabolites content (alkaloids, terpenoids, polyphenols, quinons, coumarins) that plants produce, but also with the toxic power of these biomolecules to microorganisms [35,36,38].

**CONCLUSION**

This study showed that *C. albicans* are sensitive to all the extracts in dose-response relationship. All the 15 plant species produced active extracts with more or less raised performance levels. It proves and allows the understanding of the foundation of their use in traditional recipes, against infections. However, among them, only eight species gave extracts possessing good anti-fungal properties, allowing them to neutralize pathogenic microorganisms involved in infections. These species are *E. angolense*, *H. eburnea*, *M. excelsa*, *M. villosus*, *T. catappa*, *T. ivoreensis* and *T. superba*. But the most useful plants, because their extracts are by far very active, are the four *Terminalia* species (*T. catappa*, *T. ivoreensis*, *T. mantaly*, and *T. superba*). The levels of their anti-fungal activities ranged from high to very high. Among them, the *T. superba* extracts generated the most excellent anti-candidosic activities. Furthermore, for each plant species, the hydroethanolic extracts were always noticeably 2-16 times as active as their equivalent aqueous.

Otherwise, the anti-fungal drug ketoconazole is clearly more active than most of extracts tested excepted TEKAM_{X_{aq}}, TEKAM_{X_{HE}}, TEKAM_{X_{aq}}, TEKAM_{X_{HE}}, and TEKAM_{X_{aq}} the extracts from the *Terminalia* species. In fact TEKAM_{X_{aq}}, TEKAM_{X_{HE}}, TEKAM_{X_{aq}} and TEKAM_{X_{HE}} are twice as active as ketoconazole; while TEKAM_{X_{aq}} is four times as active. This study confirms the real and strong anti-fungal activities of extracts of extract from the *Terminalia* species. Among the two solvents used for the extractions, the mixture ethanol-distilled water (70/30; v/v) is the solvent that permits the best optimization of the extraction and concentration of the active principles from a different plant species.

It would be thus desirable to continue this work by investigating more the anti-fungal potency of extracts from the four *Terminalia* species. Specifically our further works will aim the search and the isolation of compounds responsible for the anti-fungal activities as well as the determination of the chemical structure of these active principles. Our team hopes that these investigations will help to isolate new active principles that may be used in human therapeutic or to isolate metabolites that could serve as templates for synthesizing new and more active
ACKNOWLEDGEMENTS

The authors gratefully acknowledge Mr. Djo Bi of the INLOF Institute for having helped to translate the manuscript.

The authors acknowledge the technical support of the Herbarium of the floristic national center of the Felix Houphouët-Boigny University for having provided the germs used in this study.

The authors gratefully acknowledge Mr. Djo Bi of the INLOF Institute for having helped to translate the manuscript.

REFERENCES

1. Zirihi GN. Contribution au recensement, à l’identification et à la connaissance de quelques espèces végétales utilisées en médecine traditionnelle chez les Bétés du département d’Issia. Thèse de doctorat de Doctorat 3ème Cycle de Botanique, FAST. Abidjan. Côte d’Ivoire: Université Cocomy; 1991. p. 253.
2. Zirihi GN, Kra AK, Guédé-Guina F. Evaluation de l’activité antifongique de Microglossa pynaflora (Larmarck) O. kunize (Asteraceae) pymi sur la croissance in vitro de Candida albicans. Rev Méd Pharm Afr 2003;17:11-9.
3. Therzol-Ferly M. Cours de mycologie médicale pour le C.E.S de parasitologie. Faculté de Médecine-Abidjan; 1990. p. 169.
4. Develoux M, Bretagne S. Candidoses et levuroses diverses. Encyl Med Chir Mal Infect 2005;2:318-27.
5. Chabasse D. Les nouveaux champignons opportunistes apparus en médecine. Revue générale. J Mycol Méd 1994;4:9-26.
6. Ketani A, Belkhadhir ZH, Mosadik A, Faroudy M, Ababou L, Lazeq C. Traitement antifongique des candidoses systémiques. J Mycol Med 2006;16:15-25.
7. Charles D, Lourenque P, Viard JP, Drauer F, Lorholary O. Infections fongiques au cours de l’infection par le virus de l’immunodéficience humaine. Encyl Méd Chir Mal Infect 2007;8:389-419.
8. Chabasse D, Pilet M, Bouchara JP. Les moisissures opportunistes. Emergence de nouveaux champignons pathogènes en médecine. Rev Francoph Lab 2005;2005:21-34.
9. Chabasse D, Pilet M, Bouchara JP. Emergence de nouveaux champignons pathogènes en médecine. Rev Francoph Lab 2009;2009:71-86.
10. Ajello L, George LK, Kaplan W, Kaufman L. Laboratory Manual for Medical Mycology. 2nd ed. New York, USA: John Wiley and Sons, Inc.; 1963. p. 20-35.
11. Holt RJ. Laboratory test of antifungal drugs. J Clin Pathol 1975;18:767-74.
12. Guédé-Guina F, Kra AK, Bonga GM, De Souza C. Activité antimicrobiennne d’un extrait végétal contre les germes opportunists au cours du SIDA. Rev Med Pharm Afr 1995;1:13-9.
13. Yayé YG, Kra AK, Ackah AA, Djaman AJ. Evaluation de l’activité antimicrobiennne et essais de purification des principes actifs des extraits de Terminalia catappa (H. Perrier), une combretacée sur la croissance in vitro de Candida albicans. Bull Soc R Sci Liège 2011;80:953-64.
14. Ahon GM, Akapo-Akue MJ, Kra AK, Ackah JA, Zirihi GN, Djaman AJ. Antifungal activity of the aqueous and hydro alcoholic extracts of Terminalia superba Engl. on the in vitro growth of clinical isolates of pathogenic fungi. Agric Biol J North Am 2011;1:250-7.
15. Ouattara S, Kporou KE, Kra AK, Zirihi GN, Nguessan JD, Coulibaly A, et al. Antifungal activities of Terminalia ivorenssis A. Chev. bark extracts against Candida albicans and Aspergillus fumigatus. J Intercult Ethnopharmacol 2013;1:49-52.
16. Ackah JA, Kra AK, Zirihi GN, Guédé-Guina F. Evaluation et essais d’optimisations de l’activité anticandidosique de Terminalia catappa Linn. (TEKAM2), un extrait de combretacée de la pharmacopée ivoirienne. Bull Soc Roy Sci Liège 2008;77:120-38.
17. Kuetu V, Tabopda TK, Ngameni B, Nana F, Tshikalange TE, Ngadjui BT. Antimycobacterio, antibacterial and antifungal activities of Terminalia superba (Combretaceae). S Afr J Bot 2010;76:125-31.
18. Ackah JA. Evaluation et essai d’optimisation de l’activité antifongique de Terminalia catappa Lin., une combretacée de la pharmacopée ivoirienne sur la croissance in vitro de Candida albicans, Aspergillus fumigatus et Trichophyton mentagrophytes. Thèse de Doctorat d’Université. UFR Biosciences, Université de Cocody Abidjan; 2009. p. 241.
19. Kloucek P, Polelezy N, Svobodova B, Vikova E, Kosoksa L. Antibacterial screening of some Peruvian medicinal plants used in Calleria District. J Ethnopharmacol 2005;99:309-12.
20. Bonjar GH. Inhibition of clotrimazole-resistant Candida albicans by plants used in Iranian folkloric medicine. Fitoterapia 2004;75:74-6.
21. Magassouba FB, Diaio A, Kougaté M, Mara F, Mara O, Bangoura O, et al. Ethnobotanical screening and antibacterial activity of some plants used in Guinean traditional medicine. J Ethnopharmacol 2007;114:44-53.
22. Ouattara S, Kra KA, Kporou KE, Guédé-Guina F. Evaluation de l’activité antifongique des extraits de Terminalia ivorenssis TEKAM2 sur la croissance in vitro de Candida albicans. Rev Ivoir Sci Technol 2008;12:205-14.
23. Ouattara S, Kra AK, Kporou KE, Guédé-Guina F. Evaluation de l’activité antifongique des extraits de Terminalia ivorenssis TEKAM2 sur la croissance in vitro de Aspergillus fumigatus. Bull Soc Roy Sci Liège 2009;78:302-10.
24. Ouattara S, Kporou KE, Kra AK, Yapi H. Optimization of the in vitro antifungal activity of hydroalcoholic extract of Terminalia ivorenssis A. Chev. J Nat Prod Plant Resour 2013;4:29-33.
25. Silva O, Gomes ET, Wolfender JL, Marston A, Hostettkmann K. Application of high performance liquid chromatography coupled with ultraviolet spectroscopy and electrospray mass spectrometry to the characterisation of ellagitannins from Terminalia macroptera roots. Pharm Res 2000;17:1384-91.
26. Eldeen IM, Elgorashi EE, Mulholland DA, Van Staden J, Anoligian B. A bioactive compound from the roots of Terminalia sericea J. Ethnopharmacol 2006;103:135-8.
27. Steenkamp V, Fernandes AC, Van Rensburg CE. Antibacterial activity of venda medicinal plants. Fitoterapia 2007;78:561-4.
28. Ahon GM, Kra AK, Aw S, Zirihi GN, Ackah JA, Siaka S, et al. Improvement of the antifungal activity of the hydro-alcoholic extract of Terminalia superba on the in vitro growth of three pathogenic fungi. Int J Biol Pharm Al Sci 2012;10:1434-42.
29. Kporou KE, Kra AK, Ouattara S, Guédé-Guina F. Spectre anti-infectieux de MISCA-F1 sur la croissance in vitro de Candida albicans, Cryptococcus neoformans, Aspergillus fumagatus, Aspergillus flavus, Trichophyton rubrum et Trichophyton mentagrophytes. Rev Ivoir Sci Technol 2008;12:147-55.
30. Kporou KE, Kra AK, Ouattara S, Guédé-Guina F. Evaluation de la sensibilité de Candida albicans aux extraits de Mitracarpus scaber une rubiaceae codifiée MISCA. Bull Soc Roy Sci Liège 2009;78:12-23.
31. Kporou KE. Amélioration par fractionnement chromatographique de l’activité anticandidosique d’un extrait hexane de Mitracarpus scaber Zucc.sur la croissance in vitro de Candida albicans et Candida tropicalis. Phytothérapie 2010;8:290-4.
32. Kporou KE. Evaluation et amélioration par fractionnement chromatographique de l’activité anticandidosique de Mitracarpus scaber. Thèse unique. UFR Biosciences. Université de Cocody-Abidjan Côte d’Ivoire; 2010. p. 160 p.
33. Kra AK, Zirihi GN, Guédé-Guina F. Evaluation et comparaison des activités antifongiques de Fagara macrophylla et de Strychnos spinosa sur la croissance in vitro de Candida albicans. Afr Bioméd 2002;4:17-22.
34. Philibert J, Vignes A, Brechet Y, Combrade P. Metallurgie, Du Minerai Au Matériaux. 2nd ed. Paris: Dunod; 2002. p. 398-437.
35. Cowan MM. Plant products as antimicrobial agents. Clin Microbiol Rev 1999;12:564-82.
36. Karou D, Nadembega WM, Ouattara L, Ilboudo DP, Antonella C, Nikiema JB, et al. African ethnopharmacology and new drug discovery. Méd Aromat Plant Sci Biotechnol 2007;1:161-9.
37. Chaabi M. Étude phytochimique et biologique d’espèces végétales africaines: Euphorbia stenoclada Baill. (Euphorbiaceae), Anogeissus leiocarpus Guill. & Perr. (Combretaceae), Limoniastrum feei (Girard) Batt. (Plumbaginaceae). Thèse de Doctorat en Sciences de l’Université Louis Pasteur STRASBOURG, Discipline: Sciences Pharmaceutiques Spécialité: Pharmacognosie et de l’Université Mentouri de Constantine; 2008. p. 266.
38. Bowman WC, Rand MJ. Textbook of Pharmacology. 2nd ed. Oxford, England: Blackwell Scientific Publications; 1980. p. 1850.

© SAGEYA. This is an open access article licensed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/3.0/) which permits unrestricted, noncommercial use, distribution and reproduction in any medium, provided the work is properly cited.

Source of Support: Nil, Conflict of Interest: None declared.