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Original Article

Ethnobotanical Survey and Antifungal Activity of Selected Medicinal Plants Used to Treat Vaginal Infections in the Dschang District, West Cameroon

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Abstract

Background and objectives: Vulvovaginal candidiasis, an infection caused by an abnormal proliferation of *Candida* species in the vagina and vulva, is particularly relevant, affecting up to 75% of women of reproductive age. Because of antifungal drug resistance, a significant number of plants are used to treat vaginal candidoses in Cameroon. Thus, the scientific validation of the use of these plants in treating candidiasis is valuable. This study sought to identify medicinal plants used to treat vaginal infections in the Dschang district and evaluate the antifungal activity of the most promising plants on five *Candida* species.

Methods: The ethnobotanical survey was conducted in Dschang (Menoua Division, West Cameroon) through individual interviews using a semi-structured questionnaire. Extracts from seventeen plants were obtained by maceration using water or a water–ethanol solution (3:7; v/v). Antifungal activity was evaluated using the microdilution method.

Results: Forty-eight plants belonging to 33 families were identified as treating vaginal infections. Decoction and formulation of ovules were the prevalent modes of plant preparation, with leaves and bark being the predominant plant organs used. Out of thirty-four extracts tested, two (CSEHAlc and MIEHAlc) showed antifungal activity, with minimum inhibitory concentrations ranging from 0.315 to 2.5 mg/mL. The determination of the minimum fungicidal concentrations revealed the fungicidal orientation of these bioactive extracts.

Conclusions: This study identifies medicinal plants used to treat vaginal infections in Dschang and their modes of preparation. The *in vitro* antifungal screening of selected plants indicated *Mangifera indica* and *Canarium schweinfurthii* as the anti-*Candida* plants that can be further exploited for antifungal drug discovery.

Introduction

Female genital tract infections, including vulvovaginal candidiasis, are a significant public health concern due to their high prevalence and potential to cause complications, such as infertility, preterm birth, and pelvic inflammatory diseases.[1,2] Genital infections are classified into two types according to the location of the causative organism: lower infections affecting the vulva, vagina, and cervix, and upper infections located in the fallopian tubes and ovaries.[3] According to the World Health Organization, more than 375 million new cases of genital infections occur worldwide annually.[4] This high global burden has also been emphasized in recent studies comparing World Health Organization sexually transmitted infection fact sheets with emerging health information tools.[5] In Cameroon, epidemiological data are increasingly available through

Keywords: Vaginal infections; Medicinal plants; Antibiotic resistance; Antifungal activity; *Candida* species; Ethnobotanical survey.

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reports, master's dissertations, and theses, but remain outdated, as is the case for many cities, including the Dschang district. Vulvovaginal infections are mainly caused by bacteria and yeasts (mainly *Candida* species). In fact, candidiasis is known to be the most common fungal infection in humans.[6,7] Its prevalence in tropical Africa varies between 33% and 47% of opportunistic infections.[8] Among these, vulvovaginal candidiasis is reported to affect the female genital tract,[9] thus accounting for over one-third of cases of vaginitis.[10] This disease is highly recurrent, affecting between 138 and 140 million women worldwide each year,[11,12] with 70–75% of them suffering from at least one episode of vulvovaginal candidiasis per year during their lifetime.[13] Its incidence has increased 2.5-fold over the past 20 years, in contrast to gonococcal and trichomonas vaginitis, which have declined over the same period.[14] *Candida albicans*, a commensal yeast of the vaginal mucosa, remains the most implicated pathogen among *Candida* species (77–95%), followed by non-*albicans Candida* (20–30%; *Candida glabrata*, *Candida tropicalis*, *Candida krusei*, and *Candida parapsilosis*).[15,16] According to Kechia *et al*.,[17] from 397 women examined at the University Hospital of the Faculty of Medicine and Biomedical Sciences (University of Yaoundé I, Cameroon), 35.52% of cases of vulvovaginal candidiasis were recorded. Due to the presence of different forms of vaginal candidiasis, various treatments have been developed; the most recent include oteseconazole, ibrexafungerp, and voriconazole, among others.[18] However, studies have shown potential toxicity risks of most of these treatments in pediatric age groups and pregnant women.[19] Other studies have also revealed that ibrexafungerp is expensive, especially for people living in developing countries.[20] Although fluconazole is the first-line treatment for vulvovaginal candidiasis, thus improving the quality of life of over 96% of women, 63% have persistent infections after completing treatment. While voriconazole has antifungal activity against *C. albicans*, resistance has been demonstrated in other *Candida* species, notably *C. glabrata* and *C. parapsilosis*.[21] Because of drug resistance, toxicity, and the high cost of currently available antifungal drugs, there is a pressing need to search for effective treatments against multi-resistant fungal strains.

For thousands of years, humans have used various plants found in their environment to treat all kinds of diseases.[22] Many women rely on traditional medicine using herbal remedies to resolve their gynecological problems, due to perceived efficacy and reluctance to seek conventional medical care.[23] These plants represent a huge reservoir of potential compounds, which have the advantage of being highly diverse in chemical structure and possessing a very wide range of biological activities.[24] However, many of these medicinal plants are neither identified nor documented, and their traditional use has not yet received scientific validation. Thus, the present study aimed to identify and document medicinal plants that are used to treat vaginal infections in the Dschang district, and to evaluate the antifungal activity of extracts from the most utilized plants against selected *Candida* strains, including *C. albicans, C. glabrata, C. tropicalis, C. krusei*, and *C. parapsilosis*.

Materials and methods

Ethnobotanical study of plants used to treat vaginal infections in Dschang

The ethnobotanical survey was conducted among traditional healers and medicinal plant users in different localities of Dschang in the Menoua Division (West Cameroon). For this study, conventional equipment was used to gather information, and to collect and preserve the plant samples. Survey sheets, secateurs, newspapers, cardboard folders, wooden presses, and a digital camera were used. A semi-structured questionnaire (Supplementary File 1) was administered upon informed consent and availability of the traditional healers, herbalists, and traditional practitioners (e.g., herbal therapists). Once in the field, photographs of the plants were taken before collection. Grasses, trees, shrubs, and vines were the main plant materials. These materials were kept either inside clean paper or in presses for plant identification and authentication.

Location and study site

The ethnobotanical study was conducted in Dschang in the Menoua Division, West Region of Cameroon. Located at an altitude of 1,400 meters on the southeastern slope of the Bamboutos Mountains, Dschang has a microclimate (average temperature of 16 °C, maximum of 31 °C during the hottest month of April), making it suitable for agricultural and ecological studies. Dschang city is 60 kilometers (a 45-min drive) from Bafoussam (capital of the West Region), 300 kilometers (a four-hour journey) from Douala (capital of the Littoral Region), and 400 kilometers (a five-hour journey) from Yaoundé (capital of the Central Region). The municipality covers 262 km^2, with 20 communities in the urban area and 96 in the rural area. The five groups that make up the municipality are: Foto: 99 km^2; Foréké-Dschang: 86 km^2; Fongo-Ndeng: 31 km^2; Fossong Wentcheng: 18 km^2; Fotetsa: 11 km^2; Urban center: 7 km^2.[25,26]

Description of the study area

The study site is situated in Dschang in the Menoua Division (West Region of Cameroon), at latitude 5°26′36.348″ N and longitude 10°4′7.46″ E. This area falls within agro-ecological zone III of Cameroon, more specifically the Cameroon Western Highlands. The Dschang district has a mean altitude of 1,400 m above sea level.[27] The climate of Dschang is a humid tropical monsoon type with two seasons: a dry season of four months (from mid-November to mid-March) and a long rainy season of eight months (mid-March to mid-November). The average annual rainfall ranges between 1,800 and 2,000 mm. The annual temperature of Dschang ranges from 13.02 °C to 31.00 °C, with an average of 20 °C and an average thermic amplitude of 14 °C. The relative humidity of air (maximum amount of water vapor) is about 60%.[27] The study area also comprises the Menoua River watershed, which is located in Cameroon's Western Highlands, a mountainous region with volcanic soil, and is drained by a fifth-order stream (Menoua) originating from the Bamboutos Mountains. The Santchou Hills are the source of numerous streams that contribute to the river system.[28] The vegetation consists mostly of woody savannah shrubs and grassland, with some trees. In the Dschang district, the basement rocks consist of Neoproterozoic granite-gneiss, late Proterozoic granitoids intruded within the granite gneisses, and gabbroic dykes that crop out in two previous units. The composition of rocks here includes basalt, trachyte, phonolites, and granite. Agriculture is generally the main activity of inhabitants in the Western Highlands of Cameroon. In this area, the land is cultivated intensely, with little to no rest periods (fallow land), to maximize crop production on limited land. Most farmers practice mixed cropping, where maize and beans are intercropped with Arabica coffee, cassava, plantains, and bananas, among others. Hydromorphic and red ferrallitic soils are respectively found in marshy lowlands and on the midslopes.[29]

Survey approach

The survey began with an administrative approach, during which the Délégué Régional of Health of the West Region of Cameroon authorized (authorization number 1058/25/06/2025/CE/CRERSH-OU/VP) the research to be carried out among herbalists, traditional health practitioners, and people with knowledge of medicinal plants.

Meeting with the participants

Several actors of the traditional pharmacopoeia (herbalists, clairvoyants, traditional healers, holders of knowledge in traditional medicine) were met according to their willingness and availability, using a well-established survey form (semi-structured questionnaire). This included questions on the identity (age, gender, profession, level of education, etc.) of the participants, local and common names of the plant species, the organs or parts of plants used, their modes of preparation, the route of administration of the recipes, and the experience of the respondents in treating with medicinal plants, among others. Notably, clairvoyants are known for their ability to diagnose ailments through spiritual means and prescribe treatments using locally sourced herbs and traditional remedies. Participants aged <18 years, 18–30 years, 31–50 years, and >50 years were considered adolescents, young, middle-aged and senior adults, respectively.[30–32] People surveyed provided information on the use of medicinal plants to treat vaginal infections.

Plant characterization

Botanical descriptions of the medicinal plants revealed by the respondents were retrieved from the literature. Plant identification websites, such as Prota 4U (https://www.prota4u.org/, 2025),[33] and The World Flora Online (https://www.worldfloraonline.org/, 2025) were also used to identify the plants. Upon antifungal screening of selected plant extracts,[34] the authentication of the bioactive plants was confirmed at the National Herbarium of Cameroon, where a specimen was deposited.

Antifungal activity

Plant material

Upon the botanical survey, the plants most indicated for the traditional treatment of vaginal infections were selected for antifungal screening. Different organs (leaves, stems, bark, fruit, etc.), collected at the study site, were brought to the laboratory, cut into pieces, dried at room temperature, and ground to obtain a fine powder.

Microbiological material

Antifungal activity of plant extracts was determined on five reference fungal strains, including *C. albicans*, *C. glabrata*, *C. tropicalis*, *C. krusei*, and *C. parapsilosis*, kindly donated by the Centre Pasteur of Cameroon (Yaoundé, Cameroon). These *Candida* species were stored in tubes containing Sabouraud Dextrose Agar by slant culture at 4 °C and maintained in continuous culture at the Laboratory for Phytobiochemistry and Medicinal Plant Studies, Department of Biochemistry, University of Yaoundé I.

Plant extraction

The extracts were prepared by maceration of different parts of selected plants using water or water–ethanol solution (3:7; v/v). Twenty grams of each plant powder was macerated in 120 mL of water or hydroethanolic solution for 24 h. The mixtures were stirred twice a day (morning and evening), and the macerates obtained were filtered using Whatman No. 1 filter paper, then ventilated at room temperature to obtain the crude extracts.[35] These extracts were weighed, and the yields of extraction were calculated using the following formula:

$$\text{Yield of extraction (\%)} = \frac{\text{Weight of the extract}}{\text{Weight of the plant powder}} \times 100$$

The as-prepared extracts were further stored at 4 °C for evaluation of antifungal activity.

Preparation of solutions

Preparation of stock solutions of extracts

The stock solutions of the extracts were prepared at 100 mg/mL by dissolving 100 mg of each crude extract in 100% dimethyl sulfoxide. Amphotericin B was prepared under the same conditions by dissolving 1 mg of the drug in 1 mL of sterile distilled water.

Preparation of fungal inocula

The fungal inocula were prepared according to the 0.5 McFarland standard. A colony from 48-h cultures on Sabouraud Dextrose Agar was collected using a platinum loop and placed in a test tube containing 10 mL of 0.9% NaCl, and calibrated to 0.5 McFarland by comparison with the corresponding turbidity of 2.5×10^6 CFU/mL as evidenced by optical density measurement.[36]

Inhibitory effects of plant extracts

Preliminary screening

A preliminary screening of antifungal activity of extracts from selected plants was performed at a single concentration (5 mg/mL) against five *Candida* strains, including *C. albicans*, *C. glabrata*, *C. tropicalis*, *C. auris*, and *C. parapsilosis*. The inhibitory effects of the plant extracts were determined in liquid medium according to the protocol M27-A4, described in the Clinical and Laboratory Standards Institute guidelines.[36] 190 µL of Sabouraud Dextrose Broth (SDB) was added to each well of a 96-well microtiter plate, followed by 4 µL of stock solution of extracts (5 mg/mL). Then, 100 µL of a fungal suspension loaded at 2.5×10^6 CFU/mL was distributed into the test and negative control wells. The final concentration of the inoculum in each well was 5×10^3 cells/mL. The sterility control (blank) consisted of culture medium only, whereas the positive control comprised the culture medium, inoculum, and amphotericin B. The negative control comprised the culture medium and fungal inoculum. The microplates were sealed and incubated at 37 °C for 48 h. At the end of the incubation period, 20 µL of a freshly prepared resazurin solution (0.15 mg/mL) was added to all wells, followed by an additional incubation under the same conditions for 30 min. Wells in which no color change from blue (resazurin) to pink (resorufin) was observed corresponded to no growth of fungal cells.

Determination of minimum inhibitory concentrations (MICs) and minimum fungicidal concentrations (MFCs)

Determination of MICs: To determine the MICs, 190 µL of SDB was added to the first twelve wells in column A of a 96-well microtiter plate, whereas 100 µL was introduced into the remaining wells of the plate. Then, 4 µL of a sterile solution of each extract at 100 mg/mL was added to the first 12 wells, whereas 10 µL of amphotericin B (100 mg/mL) was introduced into the last three corresponding wells. This was followed by a series of five two-fold dilutions, from column A to column F. Then, 100 µL of a fungal suspension loaded at 2.5×10^6 CFU/mL was distributed into the test and negative control wells. The final inoculum concentration in each well was 5×10^3 cells/mL. The sterility control (blank)

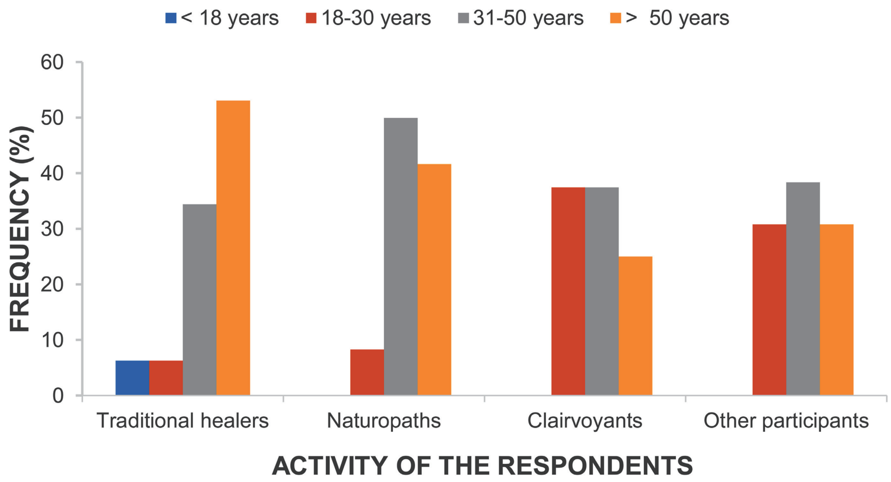

Fig. 1. Frequency distribution of different categories of participants by age. Sixty-five participants, surveyed using a semi-structured questionnaire, were assigned to age groups of <18 years, [18–30] years, [31–50] years, and >50 years. Other participants included 09 farmers, 01 student, 01 trader, 01 housewife, and 01 winemaker.

consisted of culture medium only, the positive control encompassed the culture medium, inoculum, and amphotericin B, and the negative control comprised culture medium and fungal inoculum. The microplates were covered and incubated at 37 °C for 48 h. At the end of incubation, 20 µL of freshly prepared resazurin solution (0.15 mg/mL) was added to all wells, followed by an additional incubation for 30 min under the same conditions. The lowest concentrations at which no color change from blue to pink was observed corresponded to no fungal growth and were considered the MICs, which were used to determine MFCs.

Determination of MFCs: The MFCs of plant extracts were determined in liquid medium using preparations derived from the MIC microplates. From the plates used to determine MICs, 25 µL aliquots from wells that showed no growth and were without resazurin treatment were aseptically removed and transferred to corresponding wells in another sterile microplate containing 175 µL of SDB. The contents of the wells were then diluted eight times to remove the inhibitory effect of the extracts. The sterility control consisted of culture medium only, whereas the negative control comprised the fungal inoculum and culture medium. The microplates were covered and incubated at 37 °C for 48 h. At the end of the incubation period, the plates were treated as described in subsection b.1. Tests were performed in triplicate in sterile 96-well microplates. The fungicidal or fungistatic effect of the extracts was estimated by calculation of the MFC/MIC ratio. According to Traoré *et al.*,[37] when the MFC/MIC ratio of an antimicrobial substance is ≤ 4, it is classified as fungicidal; if the ratio is > 4, the substance is classified as fungistatic.

Statistical analysis

Data obtained from the ethnobotanical survey were analyzed using Microsoft Excel version 2016, which was also used to plot graphs (histograms). Variables were presented as frequencies (counts of observations in each defined category). Quantitative data analysis was performed using one-way analysis of variance with GraphPad Prism 8.0.1 software.[38] Values were represented as mean ± standard deviation. Differences between means were compared by Dunnett's test. Samples with a P-value ≤ 0.05 were considered statistically significant. Antifungal tests were performed in triplicate for each sample (plant extract).

Results

Ethnobotanical survey

Sociodemographic profile of the participants

Source of information

The survey was conducted in the Dschang district among 65 people, including 32 traditional healers, 8 clairvoyants, 12 naturopaths, and 13 other participants (9 farmers, 1 student, 1 trader, 1 housewife, and 1 winemaker) (Supplementary Fig. 1).

Distribution of participants by gender

During this ethnobotanical survey, there was a marked interest in the use of medicinal plants among males and females. Out of 65 people surveyed, 34 participants were men and 31 respondents were women (Supplementary Fig. 2). The majority of traditional healers (81.25%) were men, while naturopaths (66.7%) and clairvoyants (100%) were predominantly women. Among the other respondents, 30.76% were men (02 farmers, 01 winemaker, and 01 trader), versus 69.23% women (07 farmers, 01 student, and 01 housewife) (Supplementary Fig. 2).

Distribution of the respondents by age

Sixty-five informants, aged between 18 and 95, were interviewed. The respondents were divided into four age groups: <18 years, [18–30] years, [31–50] years, and >50 years. The majority of traditional practitioners (53.1%) and naturopaths (41.7%) were over 50 years old. Among the clairvoyants, there was a prevalence of people aged between 18 and 30 years (37.5%) or between 31 and 50 years (37.5%) (Fig. 1).

Distribution of participants according to their level of education

This study revealed a diversity of education levels among the interviewees (Supplementary Fig. 3). The majority of informants attended up to primary school, representing 78.2%, followed by university level (12.85%) and secondary level (8.95%). The majority of traditional practitioners and clairvoyants attended school up to the primary level (Supplementary Fig. 3), which might be due to the fact that traditional healers start treating people with medicinal

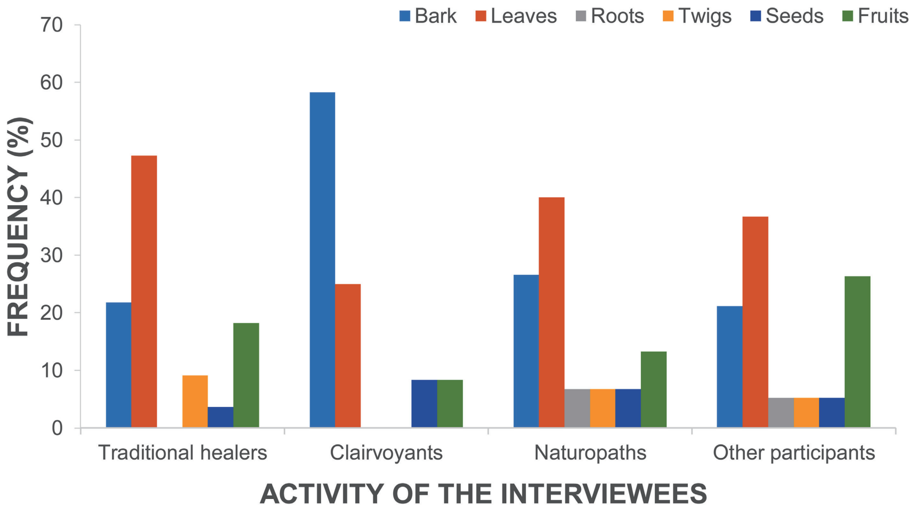

Fig. 2. Frequency distribution of plant parts used by various groups of participants. Upon the ethnobotanical survey, participants indicated bark, leaves, roots, twigs, seeds, and fruits as the main plant organs used in herbal preparations to treat vaginal infections. Other participants included 09 farmers, 01 student, 01 trader, 01 housewife, and 01 winemaker.

plants from a very early age (childhood).

Information on the use of medicinal plants to treat vaginal infections

Frequency of use of various plant organs by the respondents

Figure 2 illustrates the different organs of plants used in the treatment of vaginal infections by the informants. Most clairvoyants (58.31%) use bark in their plant preparations, compared to traditional practitioners (47.3%) and naturopaths (40%), who mostly use leaves to treat vaginal diseases. Overall, the plant parts used by different groups of participants include bark, leaves, seeds, stems, roots, and fruits (Fig. 2).

Modes of preparation of medicinal plants by the respondents

According to the survey, the majority of traditional practitioners (40.6%) use maceration as the mode of plant preparation, while among clairvoyants (37.5%), the predominant mode of preparation is decoction. Among naturopaths, ovule formulation (25%) was predominant, followed by maceration and decoction (Fig. 3).

Distribution of participants according to their experience in using plants to treat vaginal infections

The number of years of experience of participants in using medicinal plants to treat vaginal infections was also recorded (Supplementary Fig. 4). The majority of traditional healers (87.5%), naturopaths (75%), and clairvoyants (91.66%) have more than five years of experience in using medicinal plants to treat vaginal infections.

Adverse effects indicated by the respondents following the administration of different herbal preparations

Figure 4 shows the various adverse effects observed following the administration of herbal preparations by the participants. The

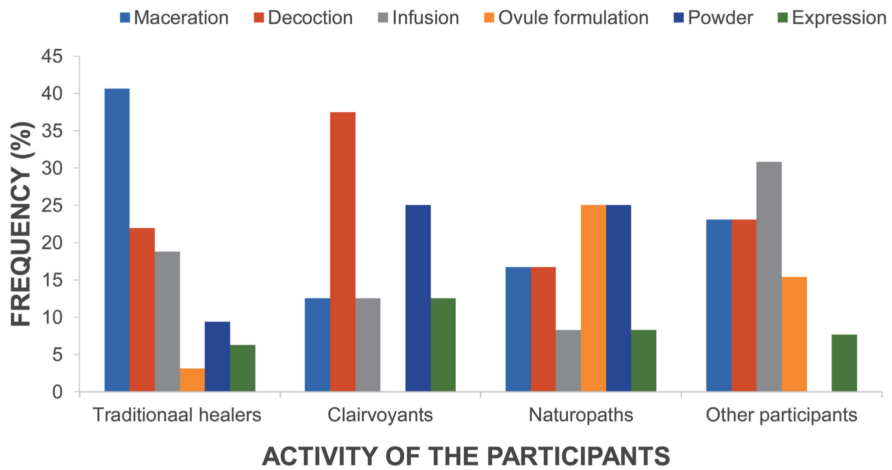

Fig. 3. Frequency distribution of modes of preparation of medicinal plants among participants. Upon the ethnobotanical survey, participants indicated bark, leaves, roots, twigs, seeds, and fruits as the main plant organs used in herbal preparations to treat vaginal infections. Other participants included 09 farmers, 01 student, 01 trader, 01 housewife, and 01 winemaker.

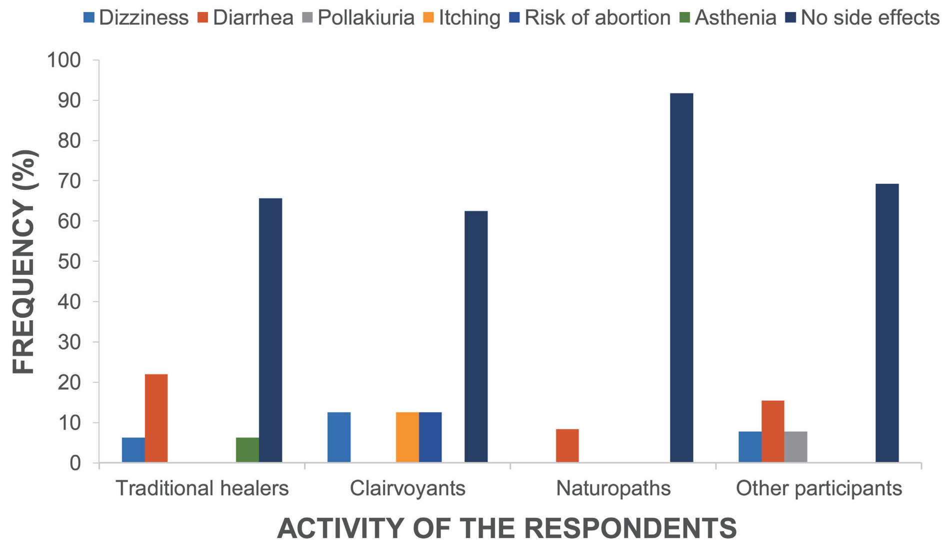

Fig. 4. Different adverse effects observed following the administration of herbal preparations by respondents. After administration of the herbal preparations to patients with vaginal infections, participants recorded dizziness, diarrhea, pollakiuria, itching, and asthenia as the main adverse effects for a few plants. The majority of plants used did not cause adverse effects. Other participants included 09 farmers, 01 student, 01 trader, 01 housewife, and 01 winemaker.

majority of plants used by all groups of participants did not present any adverse effects upon oral administration. However, some respondents reported dizziness (traditional practitioners and clairvoyants), diarrhea (traditional practitioners and naturopaths), pollakiuria (7.7% of other groups), itching (12.5% of clairvoyants), risk of abortion (12.5% of clairvoyants), and asthenia (6.25% of traditional practitioners) as notable adverse effects for certain plants (Fig. 4).

Information on medicinal plants used to treat vaginal infections in Dschang

A total of 48 plant species (Table 1) belonging to 33 different families [Asteraceae (6), Amaranthaceae (3), Fabaceae (3), Anacardiaceae (2), Burseraceae (2), Rutaceae (2), Myrtaceae (1), Piperaceae (2), Amaryllidaceae (1), Lamiaceae (1), Poaceae (2), Solanaceae (1), Liliaceae (1), Asphodelaceae (1), Araliaceae (1), Annonaceae (1), Apocynaceae (1), Caricaceae (1), Combretaceae (1), Bignoniaceae (1), Campanulaceae (1), Meliaceae (1), Malvaceae (2), Crassulaceae (1), Moraceae (1), Euphorbiaceae (1), Lauraceae (1), Cucurbitaceae (1), Hypericaceae (1), Commelinaceae (1), Urticaceae (1), Zingiberaceae (1)] were recorded by respondents as medicinal plants used to treat vaginal infections. Images of these plant species are also shown in Table 1.[39-76]

Antifungal activity

Yield of extraction

Following the ethnobotanical survey, a total of 17 mostly cited plant species were selected for anti-*Candida* screening: *Spathodea campanulata*, *Tetrapleura tetraptera*, *M. indica*, *Lannea spp.*, *Syzygium aromaticum*, *Solanum torvum*, *Toona sinensis*, *C. schweinfurthii*, *Panax ginseng*, *Ficus exasperata* Vahl, *Tabernaemontana elegans*, *Spilanthes filicaulis*, *Hibiscus cannabinus* L., *Ocimum gratissimum*, *Lobelia giberroa* Hemsl., *Leucaena glauca*, and *Allium sativum* L., which were selected for antifungal testing against five strains of *Candida* (*C. albicans*, *C. glabrata*, *C. tropicalis*, *C. auris*, and *C. parapsilosis*). These plants were extracted by maceration using either water or a mixture of water and ethanol (3:7; v/v). The yields of extraction of different plant organs are shown in Table 2.

The yield of extraction of aqueous extracts from the 17 selected plants ranged from 1.00% (*T. elegans* bark extract) to 70.30% (*A. sativum* bulb extract) (Table 2). Moreover, maceration with the hydroethanolic solution afforded extraction yields ranging from 1.05% (*F. exasperata* bark extract) to 59.50% (*O. gratissimum* leaf extract) (Table 2).

Inhibitory effects of plant extracts on the *Candida* species

Preliminary screening of antifungal activity

Table 3 presents the detailed results obtained following preliminary screening of selected plant extracts at a single concentration (5 mg/mL).

Following the preliminary screening of thirty-four (34) extracts (17 aqueous extracts and 17 water-ethanol extracts) from the seventeen (17) selected plants (*S. campanulata*, *T. tetraptera*, *M. indica*, *Lannea spp*., *S. aromaticum*, *S. torvum*, *T. sinensis*, *C. schweinfurthii*, *P. ginseng*, *F. exasperata*, *T. elegans*, *S. filicaulis*, *H. cannabinus*, *O. gratissimum*, *L. giberroa*, *L. glauca*, and *A. sativum*) against the five *Candida* species (*C. albicans*, *C. glabrata*, *C. tropicalis*, *C. auris*, and *C. parapsilosis*), nine extracts (SCEHAlc, MIE$H_2$0, MIEHAlc, LSPEH20, LSPEHAlc, SAFr$H_2$0, CSEHAlc, FEEHAlc, and TEE$H_2$0) inhibited the growth of at least one *Candida* strain at a concentration of 5,000 µg/mL. Among these extracts, two (MIEHAlc and CSEHAlc: hydroethanolic extracts from *M. indica* and *C. schweinfurthii*, respectively) inhibited almost all the *Candida* species tested and were selected for the determination of MICs and MFCs. Amphotericin B (positive control) inhibited the growth of all the *Candida* species tested (Table 4).

MICs and MFCs

Table 4 summarizes the minimum inhibitory and MFCs of extracts that showed inhibition on the majority of yeasts tested at a concentration of 5 mg/mL.

Table 1. List of medicinal plants used to treat vaginal infections in the Dschang district, West Cameroon

Scientific name of the plant	Family's name	Local name	Common name	Plant organs	Modes of preparation	Route of administration	Reference/Source
Canarium schweinfurthii	Burseraceae	Mbeuih	Black fruit	Bark	Decoction	Oral	39
Syzygium aromaticum L.	Myrtaceae	«Clove nail»	Clove nail	Seeds	Infusion, maceration	Oral, genital	39
Piper nigrum	Piperaceae	Sap (black pepper)	Black pepper	Fruits	Infusion	Oral	40
Amaranthus tricolor L.	Amaranthaceae	Panzem	Two sides	Leaves	Expression	Rectal	41
Ocimum gratissimum	Limiaceae	Village's Macep	Wild basil	Leaves	Infusion, maceration	Oral	42
Beta vulgaris	Amaranthaceae	Beet root	Beet root	Fruits	Expression	Oral	39
Cymbopogon citratus	Poaceae	Lemongrass	Lemongrass	Leaves	Infusion	Oral	43
Solanum torvum	Solanaceae	Wild eggplant	Wild eggplant	Fruits	Expression	Rectal	10742 SRF/Cam, «National Herbarium of Cameroon»
Allium sativum L.	Liliaceae	Garlic	Garlic	Pods	Ovule	Vaginal	44
Aloe vera barbadensis	Asphodelaceae	*Aloe vera*	*Aloe vera*	Leaves	Ovule	Vaginal	45
Crinum distichum Herb	Amaryllidaceae	Melan	Crinole	Leaves	Expression	Rectal	46
Panax ginseng	Araliaceae	Ginseng	Ginseng	Roots	Poudre	Oral	47
Carica papaya L.	Caricaceae	Papaya's leaves	Papaya	Leaves	Infusion	Oral	48
Mangifera indica L.	Anacardiaceae	Leaves of Mango tree	Mango tree	Bark	Decoction	Oral	49
Combretum micranthum	Combretaceae	Kinkéliba	Kinkéliba	Bark	Maceration	Oral	50
Tetrapleura tetraptera	Asteraceae	Four sides	Four sides	Fruits	Infusion, poudre	Oral, Rectal	51
ND	ND	Coup asock	Bark soop	Bark	Decoction	Oral	ND
Erigeron canadensis	Asteraceae	Mveng nguim	Canada's fleabane	Leaves	Infusion	Oral	52
Citrus limon L.	Rutaceae	Lemon	Lemon	Fruits	Decoction, expression	Oral	53
Citrus limon L. Burm.f.	Rutaceae	Citron	Citron	Fruits	Expression	Oral	54
Dacryodes edulis	Burseraceae	Leaves of the plum's tree	Plum tree	Leaves and bark	Decoction	Oral	31913/HNC, «National Herbarium of Cameroon»
Annona muricata	Annonaceae	Leaves of soursop tree	Soursop tree	Leaves	Decoction	Oral	42
Guibourtia demeisei	Fabaceae	Essinga	Essinga	Bark	Decoction	Oral	55
Amaranthus spp.	Amaranthaceae	Felon rouge	Felon rouge	Leaves	Expression	Rectal	56

(continued)

Table 1. *(continued)*

Scientific name of the plant	Family's name	Local name	Common name	Plant organs	Modes of preparation	Route of administration	Reference/Source
Spathodea campanulata	Bignoniaceae	Mefou	African Tulip tree	Bark	Decoction	Oral	22791 SRF/Cam, «National Herbarium of Cameroon»
Lobelia giberroa Hemsl.	Campanulaceae	Kepan	Mountain lobelia	Leaves	Decoction	Oral	57
Taraxacum officinale	Asteraceae	Atananana	Picenlie	Roots	Decoction	Oral	58
Toona sinensis	Meliaceae	Ngum	Chinese cedar	Bark	Decoction	Oral	59
Hibiscus cannabinus	Malvaceae	Cargo	«Le Kenaf»	Leaves	Decoction	Oral	60
Echeveria can can	Crassulaceae	Mkaah	Can can	Leaves	Infusion	Oral	ND
Acacia nilotica	Fabaceae	Nep nep	Nep nep	Fruits	Maceration	Oral	61
Piper longum L.	Piperaceae	Long pepper	Long pepper	Fruits	Maceration	Oral	62
Ageratum conyzoides	Asteraceae	King of Grass	King of Grass	Leaves	Expression	Oral	63
Ficus exasperata Vahl	Moraceae	Atoueh	«Dede»	Bark	Decoction	Oral	64
Euphorbia hirta	Euphorbiaceae	Mabeumoh	ND	Leaves	Infusion	Oral	65
Allium tricoccum	Amaryllidaceae	Wild onion	Wild onion	Roots	Expression	Rectal	66
Cinnamomum verum	Lauraceae	Cinnamon	Cinnamon	Bark	Powder	Oral	67
Cucumeropsis mannii Naudin	Cucurbitaceae	Nkacli	Pistachio	Fruits	Expression	Oral	68
Hibiscus cannabinus L.	Malvaceae	Acargo	ND	Leaves	Decoction	Oral	60
Lannea spp.	Anacardiaceae	Keukeuh	ND	Bark	Decoction	Oral	ND
Harungana madagascariensis	Hypericaceae	«Coup metie»	Blood's bark	Bark	Decoction	Oral	69
Guibourtia tessmannii	Fabaceae	Bubinga	Bubinga	Bark	Decoction	Oral	70
Spilanthes filicaulis	Asteraceae	Pantchou	Red's head	Leaves	Infusion	Oral	71
Commelina benghalensis L.	Commelinaceae	Liwouwou	Pigweed	Leaves	Decoction	Oral	72
Tithonia diversifolia	Asteraceae	Jealousy flower	Jealousy flower	Roots	Decoction	Rectal	18591SRF/Cam, «National Herbarium of Cameroon»
Pennisetum purpureum	Poaceae	Sissongo	Sissongo	Leaves	Infusion	Oral	73
Tabernaemontana elegans	Apocynaceae	Mbeumoh	Toad tree	Bark	Decoction	Oral	74
Urtica dioica L.	Urticaceae	Mbeubap	Stinging nettle	Leaves	Infusion	Oral	75
Zingiber officinale	Zingiberaceae	Ginger	Ginger	Roots	Infusion	Oral	76

ND, not determined; *Lannea spp.*, Plant of the genus *Lannea* (confirmation of the species awaited from the Cameroon National Herbarium).

Table 2. Plant extraction yields according to organs and solvents

Scientific name of the plant	Plant organs	Solvents	Yield of extraction (%)
Spathodea campanulata	Bark	Water	9.00
		Water +Ethanol (70%)	11.80
Tetrapleura tetraptera	Fruits	Water	15.00
		Water +Ethanol (70%)	23.90
Mangifera indica L.	Bark	Water	4.30
		Water +Ethanol (70%)	9.80
Lannea spp.	Bark	Water	1.75
		Water +Ethanol (70%)	5.35
Syzygium aromaticum L.	Fruits	Water	1.20
		Water +Ethanol (70%)	25.50
Solanum torvum	Bark	Water	7.30
		Water +Ethanol (70%)	7.65
Toona sinensis	Bark	Water	3.40
		Water +Ethanol (70%)	7.90
Canarium schweinfurthii	Bark	Water	7.60
		Water +Ethanol (70%)	15.20
Panax ginseng	Roots	Water	13.60
		Water +Ethanol (70%)	11.60
Ficus exasperata Vahl	Bark	Water	3.35
		Water +Ethanol (70%)	1.05
Tabernaemontana elegans	Bark	Water	1.00
		Water +Ethanol (70%)	11.80
Spilanthes filicaulis	Leaves	Water	10.20
		Water +Ethanol (70%)	3.60
Hibiscus cannabinus L	Leaves	Water	17.50
		Water +Ethanol (70%)	12.50
Ocimum gratissimum	Leaves	Water	15.00
		Water +Ethanol (70%)	59.50
Lobelia giberroa Hemsl.	Leaves	Water	15.30
		Water +Ethanol (70%)	9.30
Leucaena glauca	Bark	Water	4.60
		Water +Ethanol (70%)	15.10
Allium sativum L.	Pods	Water	70.30
		Water +Ethanol (70%)	43.00

The plants were collected in strict compliance with biodiversity protection regulations. Extraction was carried out by maceration of each plant powder in water or in a mixture of water and ethanol (3:7; v/v).

The incubation of extracts from *Mangifera indica* and *C. schweinfurthii* (MIEHAlc and CSEHAlc) with the five *Candida* species yielded MIC values ranging from 0.315 to 2.5 mg/mL (Table 4). The MIEHAlc extract (hydroethanolic extract of *M. indica* bark) was the most active, with an MIC value of 0.315 mg/mL on *C. parapsilosis* and *C. tropicalis* and 0.625 mg/mL on *C. albicans* (CPC strain). The hydroethanolic extract of *C. schweinfurthii* (CSEHAlc) revealed an MIC of 2.5 mg/mL on four yeasts out of the five tested. Overall, *C. parapsilosis* and *C. tropicalis* were the most sensitive *Candida* strains to the hydroethanolic extract of *M. indica* bark. According to the criteria reported by Tamokou *et al*.,[77] an extract is considered highly active if MIC < 100 µg/mL; significantly active if 100 ≤ MIC ≤ 512 µg/mL; moderately active if 512 ≤ MIC ≤ 2,048 µg/mL; weakly active if MIC > 2,048 µg/mL; and

Table 3. Antifungal activity of extracts from selected plants used to treat vaginal infections at the concentration of 5 mg/mL

Extracts/Fungal strains	$SCEH_20$	SCEHAlc	$TTFrH_20$	TTFrHAlc	$MIEH_20$	MIEHAlc	$LSPEH_20$	LSPEHAlc	$SAFrH_20$	SAFHAlc	$STEH_20$
C. auris	−	+	−	−	−	+	−	−	+	−	−
C. albicans (CPC strain)	−	−	−	−	+	+	−	−	+	−	−
C. parapsilosis	−	−	−	−	−	+	+	+	−	−	−
C. tropicalis	−	−	−	−	−	+	+	−	+	−	−
C. albicans	−	−	−	−	+	−	−	+	−	−	−

Extracts/Fungal strains	STEHAlc	$TSEH_20$	TSEHAlc	$CSEH_20$	CSEHAlc	$PGRH_20$	PGRHAlc	$FEEH_20$	FEEHAlc	$TEEH_20$	TEEHAlc
C. auris	−	−	−	−	+	−	−	−	−	−	−
C. albicans (CPC strain)	−	−	−	−	+	−	−	−	−	+	−
C. parapsilosis	−	−	−	−	+	−	−	−	−	−	−
C. tropicalis	−	−	−	−	+	−	−	−	−	−	−
C. albicans	−	−	−	−	−	−	−	−	+	−	−

Extraits/Souches	$SFFH_20$	SFFHAlc	$HCFH_20$	HCFHAlc	$OGFH_20$	OGF-HAlc	$LGFH_20$	LGFHAlc	$ESEH_20$	ESEHAlc	$ASGsH_20$	ASGsHAlc	Ampho-tericin B
C. auris	−	−	−	−	−	−	−	−	−	−	−	−	+
C. albicans (CPC strain)	−	−	−	−	−	−	−	−	−	−	−	−	+
C. parapsilosis	−	−	−	−	−	−	−	−	−	−	−	−	+
C. tropicalis	−	−	−	−	−	+	−	−	−	+	−	−	+
C. albicans	−	−	−	−	−	−	−	−	−	−	−	−	+

+, Active extract at 5 mg/mL; −, Not active at 5 mg/mL; $SCEH_20$, Aqueous extract of *Spathodea campanulata*; SCEHAlc, Hydroethanolic extract of *Spathodea campanulata*; $TTFrH_20$, Aqueous extract of *Tetrapleura tetraptera*; TTFrHAlc, Hydroethanolic extract of *Tetrapleura tetraptera*; $MIEH_20$, Aqueous extract of *Mangifera indica*; MIEHAlc, Hydroethanolic extract of *Mangifera indica*; $LSPEH_20$, Water extract of *Lannea* spp.; LSPEHAlc, Hydroethanolic extract of *Lannea spp.*; $SAFrH_20$, Water extract of *Syzygium aromaticum*; SAFHAlc, Hydroethanolic extract of *Syzygium aromaticum*; $STEH_20$, Aqueous extract of *Solanum torvum*; STEHAlc, Hydroethanolic extract of *Solanum torvum*; $TSEH_20$, Aqueous extract of *Toona sinensis*; TSEHAlc, Hydroethanolic extract; $CSEH_20$, Water extract of *Canarium schweinfurthii*; CSEHAlc, Hydroethanolic extract of *Canarium schweinfurthii*; $PGRH_20$, Water extract of *Panax ginseng*; PGRHAlc, Hydroethanolic extract of *Panax ginseng*; $FEEH_20$, Aqueous extract of *Ficus exasperata*; FEEHAlc, Hydroethanolic extract of *Ficus exasperata*; $TEEH_20$, Aqueous extract of *Tabernaemontana elegans*; TEEHAlc, Hydroethanolic extract of *Tabernaemontana elegans;* $SFFH_20$, Aqueous extract of *Spilanthes filicaulis*; SFFHAlc, Hydroethanolic extract of *Spilanthes filicaulis*; $HCFH_20$, Water extract of *Hibiscus cannabinus*; HCFHAlc, Hydroethanolic extract of *Hibiscus cannabinus*; $OGFH_20$, Water extract of *Ocimum gratissimum*; OGFHAlc, Hydroethanolic extract of *Ocimum gratissimum*; $LGFH_20$, Aqueous extract of *Lobelia giberroa*; LGFHAlc, Hydroethanolic extract of *Lobelia giberroa*; $ESEH_20$, Aqueous extract of *Leucaena glauca*; ESEHAlc, Hydroethanolic extract of *Leucaena glauca*; $ASGsH_20$, Aqueous extract of *Allium sativum*; ASGsHAlc, Hydroethanolic extract of *Allium sativum*.

Table 4. Minimum inhibitory and minimum fungicidal concentrations (mg/mL) of active extracts

Extracts	Parameters	*C. auris*	*C. albicans* (CPC strain)	*C. parapsilosis*	*C. tropicalis*	*C. albicans*
MIEHAlc	MIC	2.5 ± 0.0***	0.625 ± 0.0****	0.315 ± 0.0****	0.315 ± 0.0****	–
	MFC	–	–	0.315 ± 0.0	0.625 ± 0.0	–
	r	–	–	1.0	2.0	–
CSEHAlc	MIC	2.5 ± 0.0***	2.5 ± 0.0***	2.5 ± 0.0***	2.5 ± 0.0***	–
	MFC	–	–	–	5.0 ± 0.0	–
	r	–	–	–	2.0	–
Amphotericin B (µg/mL)		12.5 ± 0.0	12.5 ± 0.0	12.5 ± 0.0	12.5 ± 0.0	12.5 ± 0.0

***$P < 0.001$, ****$P < 0.0001$; Values are significantly different compared to the value obtained for amphotericin B (Dunnett's multiple comparisons test); *C.*, *Candida*; CPC, Centre Pasteur of Cameroon; MIC, minimum inhibitory concentration; MFC, minimum fungicidal concentration; r, MFC/MIC ratio; –, not determined.

inactive if MIC > 10 mg/mL. Therefore, the hydroethanolic extract of *M. indica* bark (MIEHAlc) is significantly active against *C. parapsilosis* and *C. tropicalis*, whereas the hydroethanolic extract of *C. schweinfurthii* (CSEHAlc) is weakly active against all yeasts tested (Table 4). Furthermore, the fungicidal or fungistatic effect of the extracts was estimated by the MFC/MIC ratio according to Traoré *et al*.'s criteria.[37] Thus, CSEHAlc and MIEHAlc extracts presented MFC/MIC ratios less than or equal to four (≤4). According to Traoré *et al*.,[37] when the MFC/MIC ratio of an antimicrobial substance is ≤4, it is classified as fungicidal; if the ratio is >4, it is classified as fungistatic. Accordingly, CSEHAlc and MIEHAlc extracts showed fungicidal activity on *C. tropicalis* (Table 4).

Discussion

Female genital tract infections are a global public health problem due to their high prevalence, serious consequences for women's reproductive welfare (infertility, pregnancy complications), and transmission to infants. Vaginal diseases caused by *Candida* species are fungal threats with high prevalence among all vaginal infections. The treatment of vaginal *Candida* infections is primarily based on the use of antifungal drugs, such as fluconazole, clotrimazole, and miconazole, etc.[78] However, fungal resistance is one of the main limitations that makes these treatments less effective, in addition to the development of a number of adverse effects.[79] Thus, there is a pressing need to search for effective treatments against vaginal infections. Medicinal plants are a well-recognized and often low-cost source of active ingredients for treating vaginal infections, with a growing body of evidence supporting their efficacy against various pathogens.[80,81] Many women rely on the traditional system of medicine using herbal remedies to resolve their gynecological problems due to cost, cultural beliefs, accessibility, perceived efficacy, and the feeling of embarrassment in presenting medical conditions to conventional doctors.[23] However, information on the use of medicinal plants in treating vaginal infections is not well documented. Moreover, there is a significant lack of scientific evidence to support the traditional use of numerous medicinal plants. Thus, this study aimed to identify and document medicinal plants used to treat vaginal infections in the Dschang district and to validate the traditional use of the most cited plants through *in vitro* antifungal tests.

Upon an ethnobotanical survey, a total of 65 people were interviewed, including 32 traditional practitioners, 8 clairvoyants, 12 naturopaths, and 13 other participants. The interviewees were dominated by men (34) compared to women (31). This observation may be due to women's reluctance in providing information on the use of medicinal plants or their hesitation to take part in the study.[82] The most represented participants were aged above 50 years. The predominance of older respondents indicates a lack of interest in traditional

medicine among young people, possibly because traditional practices are rooted in ancestral culture and are less relevant to younger generations.[83] Moreover, the most commonly used plant organs included leaves and bark, whereas the modes of plant preparation were dominated by decoction and ovule formulation.

Notably, a total of forty-eight (48) plant species belonging to 33 families (Table 1) were identified as being used to treat vaginal infections in the Dschang district. Among these plants, seventeen species were most cited by the respondents (*S. campanulata*, *T. tetraptera*, *M. indica*, *Lannea spp.*, *S. aromaticum*, *S. torvum*, *T. sinensis*, *C. schweinfurthii*, *P. ginseng*, *F. exasperata*, *T. elegans*, *S. filicaulis*, *H. cannabinus*, *O. gratissimum*, *L. giberroa*, *L. glauca*, and *A. sativum*) and were selected for evaluation of antifungal activity against five *Candida* species (*C. albicans, C. glabrata, C. tropicalis, C. auris, and C. parapsilosis*) responsible for vaginal infections. Plant extracts were obtained by maceration using water or hydroethanolic solution (3:7, v/v) and then subjected to antifungal screening at a concentration of 5 mg/mL. From these extracts, two (CSEHAlc and MIEHAlc: hydroethanolic extracts of *C. schweinfurthii* and *M. indica*, respectively) inhibited the growth of the majority of the *Candida* species and were subjected to MIC and MFC determinations.

The MIEHAlc extract was the most active, with a common MIC value of 0.315 mg/mL on *C. parapsilosis* and *C. tropicalis*. The hydroethanolic extract of *C. schweinfurthii* (CSEHAlc) showed an MIC value of 2.5 mg/mL when tested against all the *Candida* species. CSEHAlc and MIEHAlc revealed a fungicidal effect on *C. parapsilosis* and *C. tropicalis*, as their MFC/MIC ratios were less than or equal to four (≤4). *Mangifera indica* is reported to contain secondary metabolites, such as phenols and polyphenols,[84] whereas *C. schweinfurthii* is very rich in flavonoids, terpenoids, phenols, and alkaloids, among others.[85] Thus, it is reasonable to speculate that the antifungal activity observed in *M. indica* and *C. schweinfurthii* might be due to the presence of these secondary metabolites. Notably, previous studies have shown that flavonoids, alkaloids, and phenolic compounds exert antifungal action by inhibiting DNA synthesis, biofilm formation, and cell wall development.[86,87] The antifungal activity observed in this study might be attributed to at least one of these mechanisms. These results suggest that extracts from *M. indica* and *C. schweinfurthii* possess antifungal activity and could serve as a potential source of active ingredients for the discovery of drugs against vaginal *Candida* infections.

Limitations and perspectives

The present study aimed to identify medicinal plants used to treat vaginal infections in the Dschang district and to evaluate the antifungal activity of the most promising plants on five *Candida* species. Forty-eight (48) plant species belonging to 33 families were identified as plants used by respondents (traditional practitioners, naturopaths, etc.) to treat vaginal infections in Dschang. *In vitro* antifungal screening of selected plants indicated M. *indica* and *C. schweinfurthii* as the anti-*Candida* plants that could be further exploited for antifungal drug discovery. However, more research is needed to authenticate the majority of the plants identified and evaluate the antifungal activity of the other documented plants. Since it is essential that anti-*Candida* plant extracts be thoroughly investigated chemically to identify their active ingredients, further studies on isolation and characterization of the active principles are of outstanding importance. Toxicity and pharmacokinetic studies of the most promising plant extracts (*M. indica* and *C. schweinfurthii*), as well as their antifungal modes of action (inhibition of fungal cell walls and efflux pumps), should be investigated to ensure the successful utilization of these plants for antifungal drug discovery.

Conclusions

In this study, the medicinal plants used traditionally to treat vaginal infections in the Dschang district were identified and documented through an ethnobotanical survey. Decoction and ovule formulation were the most commonly used modes of plant preparation, with leaves and bark being the most commonly used plant organs. Among the water and hydroethanol extracts obtained from the most cited plants (17 plants), two extracts (CSEHAlc and MIEHAlc) from *M. indica* and *C. schweinfurthii* showed promising antifungal activity against selected *Candida* species, with low MIC values. Determination of the MFCs confirmed the fungicidal effect of these extracts. This novel contribution demonstrates the ethnobotanical use of plants in treating vaginal infections and validates their traditional use through *in vitro* antifungal assays. Nonetheless, more research is needed to authenticate the majority of the recorded plants at the National Herbarium of Cameroon and to evaluate the antifungal activity of the other documented plants. *In vitro* toxicity studies of *M. indica* and *C. schweinfurthii* extracts, as well as investigation of their antifungal modes of action, are warranted for the successful utilization of these plants in antifungal drug discovery.

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Conflict of interest

The authors declare no conflicts of interest.

Author contributions

Study concept and design (BPK, FFB), acquisition of data (ASML, YNN, JAK, SPT, AMM, CADN, AJN), analysis and interpretation of data (ASML, YNN, JAK, SPT, AMM, CADN, AJN), critical revision of the manuscript for important intellectual content (BPK, FFB), administrative, technical, or material support (ASML, YNN, JAK, SPT, AMM, CADN, AJN), and study supervision (BPK). All authors have read and agreed to the published version of the manuscript.

Ethical statement

This research involving human participants was carried out in adherence to the principles of the World Medical Association Declaration of Helsinki (as revised in 2024). Prior to the commencement of the study, the research protocol was reviewed and approved by the Western Regional Ethics Committee for Human Health Research in Cameroon (CRERSH-West) (ID No. 1058/25/06/2025/CE/CRERSH-OU/VP). Participation in the ethnobotanical survey was voluntary, and informed consent was obtained from every participant. The health, dignity, and rights of research participants take precedence over the interests of science and society.

Data sharing statement

Data are available from the corresponding author upon reasonable request.

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