



# The Ethnobotanical Investigation, Phytochemistry and Antioxidant Activity of a Medicinal Plant Recipe Directed against *Candida albicans* and Enterobacteria Stains Producing ESBL CTX-M-15 Type in Burkina Faso

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## Authors' contributions

This work was carried out in collaboration among all authors. Author MJB led the ethnobotanical survey, analyses and supervision; Author KJZ was in charge of the phytochemical and antimicrobial activities; Author PAEDS who directed the extractions; Author BT was in charge of collections, tests in the Laboratory and documentary research. All authors read and approved the final manuscript.

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## ABSTRACT

**Aims:** The objectives are to carry out an ethnobotanical survey among traditional healers in order to choose the most recipe used in the treatment of vaginal candidiasis in cities of Burkina Faso followed by phytochemical quantification, antioxidant activity and antimicrobial of the best recipe.

**Methodology:** Ethnobotanical surveys were conducted in Bobo-Dioulasso and Dédougou by semi-structured interview amount traditional healers. The extracts were obtained by ethanolic and hydroethanolic maceration. Characterization of the secondary metabolites was revealed by the tests in tubes. Polyphenolic compounds contents quantification was done by spectrophotometry using Follin-Ciocalteu reagent, aluminum trichloride and vanilic acid. The antioxidant activity was evaluated by two methods: DPPH• and FRAP. The Minimal inhibitory concentration on Enterobacteria strains was determined by the dilution method and the minimal bactericidal concentration was determined by inoculation on agar. The susceptibility test of *Candida albicans* strains was carried out using the disc diffusion assay.

**Results:** In total, 52 traditional healers were surveyed with a predominance of men (75%) in the both cities. 38 recipes of medicinal plants have been obtained. Decoction is the most frequent method of preparation in Bobo-Dioulasso (87.5%) and in Dédougou (27.27%). The leaves (44%) and the bark of the trunk (31.82%) are respectively the most parts used of the plants. Colorimetric tests revealed the presence of compounds such as flavonoids, alkaloids, tannins and saponosides. The best results of quantification tests of total phenolics, flavonoids and tannins, were obtained with the hydroethanolic extract (80.27±20.27(mgEAG/10 mg); 0.27±0.01(mgEQ/10 mg) and 73.31±4.65 (mgEC/10 mg)). With antioxidant activity, the highest value was obtained with the DPPH radical inhibition method (85.59±0.001%). Minimal inhibitory concentration revealed that the highest value was 0.781 mg/ml and the best minimal bactericidal concentration was 3.123 mg/ml.

**Conclusion:** Phytochemical and biological analysis realized could be partially justified by the recipes used in the treatment of vaginal candidiasis.

**Keywords:** Investigation; vaginal candidiasis; polyphenols, antioxidant.

## 1. INTRODUCTION

Vaginal candidiasis is one of the most common female infections and affects 138 to 140 million women every year worldwide [1-2]. In tropical Africa, its prevalence varies between 33 and 47% of opportunistic infections [2]. In Burkina Faso, these candidiases affect more than 179,000 women per year [3]. It is a pathology caused by fungal agents that constitute a major public health risk [4]. Furthermore, it is the species *Candida albicans*, an opportunistic fungus, very virulent in immunocompromised people who are responsible for it [5-7].

The treatment of this pathology is done through conventional medicine by the use of antifungals such as amphotericin B and azoles (fluconazole, itraconazole, voriconazole) which are often expensive and inaccessible to the population

[8-12]. In addition, *Candida albicans* develops resistance and/or recurrences which render the treatment ineffective [13,14,4]. However, according to the WHO [15] more than 80% of the population use traditional medicine for their primary health care. Thus, this medicine could be an alternative care for humanity. Also, several authors have shown that the heritage of plant biodiversity has compounds with antifungal properties such as flavonoids, tannins, phenol acids, coumarins, saponosides [16,17]. It is in this perspective that the present study was initiated with the aim of carrying out an ethnobotanical survey among traditional healers to identify the recipes of medicinal plants used in the treatment of vaginal candidiasis in order to study (i) the phytochemistry, (ii) the antioxidant and antimicrobial activities of the selected recipe.

## 2. MATERIALS AND METHODS

### 2.1 Study Framework

Ethnobotanical surveys were conducted in two towns in Burkina Faso. All the activities were carried out at the Ecotoxicology Laboratory of the Environment and Agricultural Research Institute (INEAR/NCRST) in Bobo-Dioulasso, at the Food and Nutritional Biotechnology Laboratory and at the Research Center in Biological Food and Nutritional Sciences in Ouagadougou.

### 2.2 Plant Material

The plant material consisted of fruits of *Acacia nilotica* (Linn) Willd. ex. Del. The collection took place in the month of April 2022 in the classified forest of Dindéresso. The species was previously identified on the site [www.plantlist.com](http://www.plantlist.com) before the samples were taken. Then, at the Laboratory, the samples were washed and spread out on the benches for drying for three weeks under ventilation sheltered from the sun. Spraying was carried out with an aluminum mortar to obtain powder. This powder obtained was packaged and labeled in zip bags which were used for the various operations in the laboratory following the method of Nguemo Dongock et al., [18].

### 2.3 Microbial Strains

The microbial material consisted of *Candida albicans* and Gram-negative bacteria consisting of: *Escherichia coli* Castellani and Chalmers, *Shigella sonnei* (Levine 1920) Weldin 1927, *Salmonella sp* Lignières 1900, *P. aeruginosa* (Schroeter 1872) Migula 1900, *Citrobacter freundii* (Braak 1928) Werkman and Gillen 1932, *Klebsiella pneumonia* (Schroeter, 1886) Trevisan, 1887, *Acinobacter Baumannie* str. 1656-2, *Salmonella Typhi* (Loeffler 1892) Castellani and Chalmers 1919, *Citrobacter sp* Werkman and Gillen, 1932. All these strains were isolated from vaginal samples, urine, pus and stool from all kinds of patients received at the Bacteriological Laboratory of SCHIPHRA Hospital.

### 2.4 Reagents and Solvents

The reagents and solvents used during the manipulations were the following: ascorbic acid, ferric chloride (FeCl<sub>3</sub>), aluminum chloride (AlCl<sub>3</sub>), quercetin, 2,2-diphenyl-1-picrylhydrazyl (DPPH), Folin-Ciocalteu reagent, gallic acid, sodium carbonate, ethanol, sodium chloride, glycerol,

distilled water, bleach, concentrated hydrochloric acid (HCl), magnesium (Mg), vanilic acid, trichloroacetic acid, potassium hexacyanoferrate [K<sub>3</sub>Fe (CN)<sub>6</sub>], catechol.

### 2.5 Ethnobotanical Survey

The surveys were conducted during a period between November 15, 2021 and February 20, 2022 among traditional healers in the city of Bobo-Dioulasso and Dédougou. Among the traditional healers surveyed, some belonged to an association (the *Jigi Sèmè*: association in Bobo-Dioulasso and the *Soong-Taaba*: association in Dédougou). The approach used was a semi-structured interview in the local language (*mooré* and *bôbô*) using a mini questionnaire sheet (appendix). A semi-structured interview was done with the traditional healers who agreed to answer our questions. The survey sheet included questions on the local name of the species, the plant organs used, their methods of preparation and administration.

### 2.6 Extraction

15 g of vegetable powder were weighed and introduced into an erlenmeyer flask which previously contained 150 ml of pure ethanol for the ethanolic extraction and 150 ml 20% of ethanol for the hydroethanolic extraction under stirring for 48 hours. After filtration, the filtrate was evaporated then concentrated and poured into empty Petri dishes previously weighed and labeled for drying in the oven (Evenamede et al. [19]). The yield (R) of the extractions was calculated by the following formula:  $R = (\text{Mass of the extract}) / (\text{Sample mass}) * 100$

### 2.7 Determination of Polyphenolic Compounds

#### 2.7.1 Characterization of chemical groups

Phytochemical screening consisted of highlighting the presence of certain chemical groups in the extracts obtained using the tube tests described by Nga et al. [20]: alkaloids (Dragendorff's reagent), flavonoids (Shibata test), tannins (2% of FeCl<sub>3</sub>) and saponins (foam index).

#### 2.7.2 Quantifications of total phenolics

- Assay of total phenolics: Total phenolic compounds were estimated using the Folin-Ciocalteu method described by

Singleton et al. [21]. The sample solution was diluted to the nearest  $1/10^{\text{th}}$  from the stock solution. To a volume of 100  $\mu\text{l}$  of extract, we added a volume of 400  $\mu\text{l}$  of folin-ciocalteu reagent and a volume of 420  $\mu\text{l}$  of sodium carbonate ( $\text{NaCO}_3$ ). the solution obtained is then incubated at  $37^\circ\text{C}$  for 1 h 30 min. The absorbance was read at the end of the incubation with a UV-visible spectrophotometer at 760 nm against a blank consisting of 100  $\mu\text{l}$  of extract, 400  $\mu\text{l}$  of ethanol and 420  $\mu\text{l}$  of sodium carbonate ( $\text{NaCO}_3$ ) prepared at a concentration of 0.9 mg/ml. gallic acid is used as a reference standard for establishing the calibration curve and for quantifying the total polyphenol content. the results are expressed in mg EAG/10 mg of extract.

- Assay of total flavonoids: The method used is that described by Arvouet-Grant et al. [22]. A volume of 500  $\mu\text{l}$  of the extract solution from each sample then 500  $\mu\text{l}$  of  $\text{AlCl}_3$ (2%) were placed in each tube (3). Another tube is considered as the control and which received 500  $\mu\text{l}$  of the extract solution and 500  $\mu\text{l}$  of ethanol then incubated for 15 min in the dark. Quercetin is used as a reference standard and for the quantification of flavonoid contents, the values are expressed as mg EQ/10 mg of extract. After incubation, three readings are taken for each extract sample using a spectrophotometer at a wavelength of 415 nm. The result given is an average of the three. The equation of the curve is:  $y = 34.595x + 0.0189$ ;  $R^2=0.9981$ .
- Dosage of total tannins: The reference method of the European Community for the determination of tannins [23] was used. A quantity of 200  $\mu\text{l}$  of each hydroethanolic extract was added to 1000  $\mu\text{l}$  of the vanillin solution ( $c=0.06$  mg/ml) against a blank consisting of 1000  $\mu\text{l}$  of vanilin and 200  $\mu\text{l}$  80% of ethanol. The mixture obtained is incubated in the dark to react at room temperature for 20 min. Absorbance was measured at a wavelength of 500 nm. Three tests were carried out for each sample. A stock solution of catechol was used as a reference standard for establishing the calibration curve and for quantifying the tannin content, then the results are expressed as mg EC/10 mg of dry matter. The calibration curve is:  $y = 0.1239x + 0.0005$  with  $R^2=0.9986$ .

## 2.8 Antioxidant Activities

### 2.8.1 Reducing power of iron by the FRAP method

The reducing power of the extracts is determined by the Fluorescence Recovery After Photobleaching (FRAP) method [24]. 0.5 ml of extract is mixed with 1.25 ml of phosphate buffer (0.2 M; pH=6.6) and 1.25 ml of potassium hexacyanoferrate [ $\text{K}_3\text{Fe}(\text{CN})_6$ ] at 1%. The mixture is placed in a water bath at  $50^\circ\text{C}$  for 30 minutes and then 1.25 ml of 0.1% trichloroacetic acid is added thereto. The tubes are centrifuged at 3000 rpm for 10 minutes. Then, 125  $\mu\text{l}$  of the supernatant of each tube is mixed with 25  $\mu\text{l}$  of  $\text{FeCl}_3$  (0.1%) solution and 125  $\mu\text{l}$  of distilled water then left to stand in the dark for 15 minutes before measuring the absorbances at 700 nm against a blank composed of 250  $\mu\text{l}$  of distilled water and 25  $\mu\text{l}$  of  $\text{FeCl}_3$  (0.1%). Ascorbic acid is used to draw the reference standard curve expressed in mmolEAA/10 mg.

### 2.8.2 Anti-radical activity by the DPPH radical inhibition method

The determination of the antiradical activity by the 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) test was carried out using the method described by Dieng et al. [25]. In test tubes we introduced 400  $\mu\text{l}$  of the diluted solution (extract) and 800  $\mu\text{l}$  of a DPPH solution (10 mg/50 ml of ethanol) then incubated for 15 min in the dark. A blank was prepared with 400  $\mu\text{l}$  of ethanol and 800  $\mu\text{l}$  of the DPPH solution. Absorbances and concentrations were read using a spectrophotometer at 517 nm.

## 2.9 Antimicrobial Tests

- Preparation of the standard inoculum: For each germ previously inoculated into petri dishes containing Sabouraud agar, an isolated colony is removed using a loop 2 mm in diameter and then homogenized in 10 ml of sterilized 0.9% NaCl solution.
- Preparation of culture media: All culture media, namely: Muller Hinton (MH) agar; Muller Hinton broth; Sabouraud agar; Luria-Bertani (LB) were prepared according to the manufacturers' instructions.

### 2.9.1 Susceptibility test of *Acacia nilotica* on strains of *Candida albicans*

This test is carried out according to the method of Arias et al. [26] with some modifications. After

the solidification of the Sabouraud agar in the petri dishes, a certain quantity of inoculum is poured into each petri dish so as to flood the boxes with the germs and then leave them to dry near the flame for 30 minutes. After this step, the sterile Wathman n°5 paper discs, 6 mm in diameter, are placed in the petri dishes using a sterile brush on which 10 µl of each extract diluted at different concentrations have been deposited, then an antifungal such as nystatin was used as positive control and 80% ethanol considered as negative control were added, the whole is incubated for 72 h. After incubation, sensitivity was measured using a ruler.

### 2.9.2 Determination of minimum inhibitory concentration (MIC)

The minimum inhibitory concentration was determined according to the method of Arias et al., [26] after an incubation time of 18 to 24 hours. This test was carried out by determining the turbidity with respect to the 11<sup>th</sup> well which is the control induced by the growth of the germs studied. The stock solutions of the extracts were prepared by dissolving 500 mg of dry extract in 100 ml of distilled water. Thus, the MIC corresponds to wells where there is no turbidity. Using a micro pipette, each well (the 96-well plates) received 100 µl of MH broth and 100 µl of plant extract is put in the very first wells of the plate with which a cascade dilution was performed up to the 12<sup>th</sup> well skipping every 11<sup>th</sup> well. Thus, 100 µl of inoculum of each bacterium was added. After incubation of the plates at 37°C for 18 to 24 hours, the reading of the turbidity was done with the naked eye.

### 2.9.3 Determination of the minimum bactericidal concentration (MBC)

The MBC is defined as the smallest concentration at which the extract prevents growth of bacteria after subculturing [27]. This technique was performed by taking 100 µl from each clear well and then introducing it into the Petri dish containing Muller Hinton (MH) agar. For inoculation, sterile Petri dishes previously poured with MH agar are inoculated by plating using a sterile rake; the inoculation is carried out in such a way as to ensure a homogeneous distribution of the bacteria. After 18 to 24 h of incubation at 37°C, the MBC was determined by counting colonies.

## 2.10 Statistical Analyses

All the data obtained were processed and analyzed with Microsoft Excel 2016 software.

The data collected on the survey sheets were sociodemographic and ethnobotanical characteristics. The citation frequency (Fc) of each plant was determined by the following formula:  $Fc = Nc/Nt$ ; With Nc: number of citations of the most cited plant and Nt: total number of people surveyed.

## 3. RESULTS AND DISCUSSION

### 3.1 Ethnobotanical Survey

#### 3.1.1 Distribution of traditional healers by gender

The ethnobotanical surveys made it possible to interview 52 traditional healers, including 36 in Bobo-Dioulasso against 16 in Dédougou with a predominance of the male gender, i.e., 75% in the two cities (Fig. 1). Although our sample size is small, we find that both genders practice traditional medicine in these cities. Other researchers from Burkina Faso such as Traoré et al. [28] who worked on the medicinal plants used in the treatment of malaria in Banfora found on a sample of 45 traditional healers 91.11% of men. In terms of participation in relation to gender, we find that the male gender predominates. This is found in the locality of Benin where Guinnin et al. [29], by conducting an ethnobotanical study on medicinal plants used in the traditional treatment of viral hepatitis B and C obtained a predominance of 60.97% of men. After analyzing her results, we note that the low proportion observed among women could be due to the fact that in Africa, certain ritual practices are often associated [30]. In addition, women are generally taken up with household chores, which considerably limit their integration into the practice of traditional medicine.

#### 3.1.2 Distribution of medicinal plants according to species

The ethnobotanical surveys carried out made it possible to identify 38 species used in the composition of 38 medicinal plant recipes (Fig. 2). From these results, we note that in terms of contribution of species in the recipes, the most cited were respectively *Acacia nilotica* (11.5%), followed by *Balanites aegyptiaca* (L.) Delile, *Calotropis procera* (Ait.) Ait. F., *Crescentia cujete* L. and *Zanthoxylum Zanthoxiloide* (Lam.) Watermann with a frequency of 11% each. These frequencies could be explained by the fact that traditional healers are unanimous on the use of certain species and in addition they have

regular and effective knowledge of the therapeutic virtues of these plants. Other authors such as Lema et al. [31]; Sawadogo et al. [32] and Thiombiano et al. [33] have also found the involvement of these species in the composition of recipes against ulcers, hepatitis and breast cancer.

### 3.1.3 Distribution of medicinal plants according to family

The medicinal species identified belong to 25 botanical families (Fig. 3) whose analysis reveals that the Fabaceae (18) and Phylanthaceae (18) families are the most represented in the city of Bobo-Dioulasso. The studies carried out by Kpodji et al. [34] in southern Benin on medicinal plants used in the treatment of inflammatory diseases, through a series of ethnobotanical surveys of 42 herbalists had shown that out of 28 different botanical families, the most represented were respectively the families of Euphorbiaceae and Fabaceae. This approximation of families would indicate that the species of these families are the most sought after by populations in the treatment of various pathologies including microbial infections.

### 3.1.4 Distribution of medicinal plants according to the parts used

Various plant organs are used in traditional medicine for the treatment of vaginal candidiasis. In our case, all parts of the plant are involved in the composition of the recipes (Fig. 4). It appears that in Bobo-Dioulasso, the leaves (44%) and roots (22%) constitute the most used parts of the

plant, while in Dédougou, the bark of the trunk (31.82%) and the des roots (18.18%) are the most used. These results are close to those of Dakio et al. [35] which showed that a diversity of plant organs is used with a dominance of leaves (36%). Therefore, we can say that in Bobo-Dioulasso, traditional healers are concerned about the preservation of nature, which would justify the strong use of leaves in the composition of recipes against candidiasis.

### 3.1.5 Distribution of medicinal plants according to the method of preparation

During the survey, three methods of preparation were the most cited, of which decoction is the most common method in the two cities (Fig. 5). As a result, it appears that the most common method of preparation in Bobo-Dioulasso is the decoction with a citation rate of 87.5% followed by the method of powder added to *Vitellaria paradoxa* C.F.Gaertn butter 5%. In addition, in Dédougou, the most used methods are decoction and calcination (27.27%) followed by calcination with added *Vitellaria paradoxa* C.F.Gaertn butter (22.73%). These results are similar to those of the work of Lema et al. [31] who showed that out of 290 traditional healers surveyed (Bobo-Dioulasso, Boromo, Dédougou and Fada N'Gourma) that the decoction (70%) was the main mode of preparation of these recipes. Also, Zerbo et al. [36] (in the North-West of Burkina Faso) showed that the decoction (58%) was the method most frequently used. Following these findings, these methods seem to be the easiest to perform and can reduce the toxicity of the extracts.

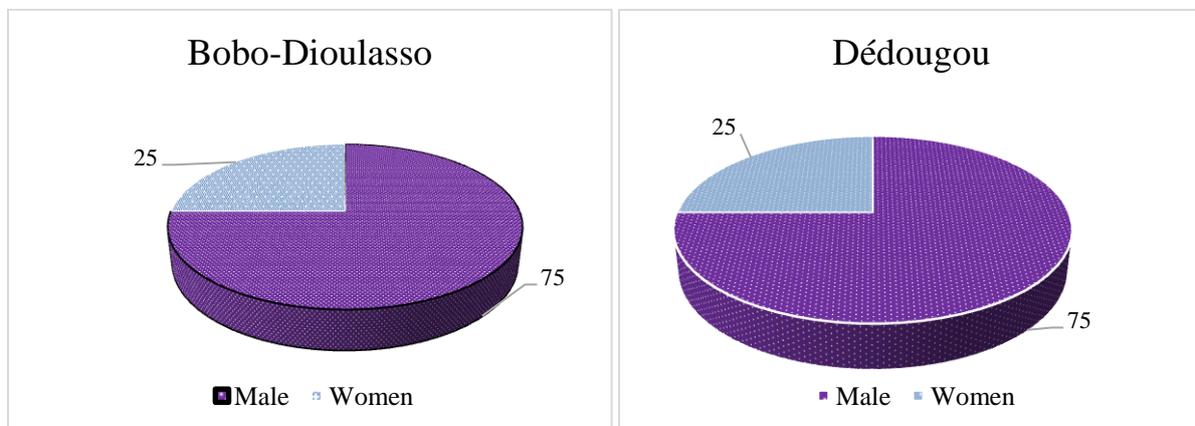


Fig. 1. Distribution of traditional healers by gender

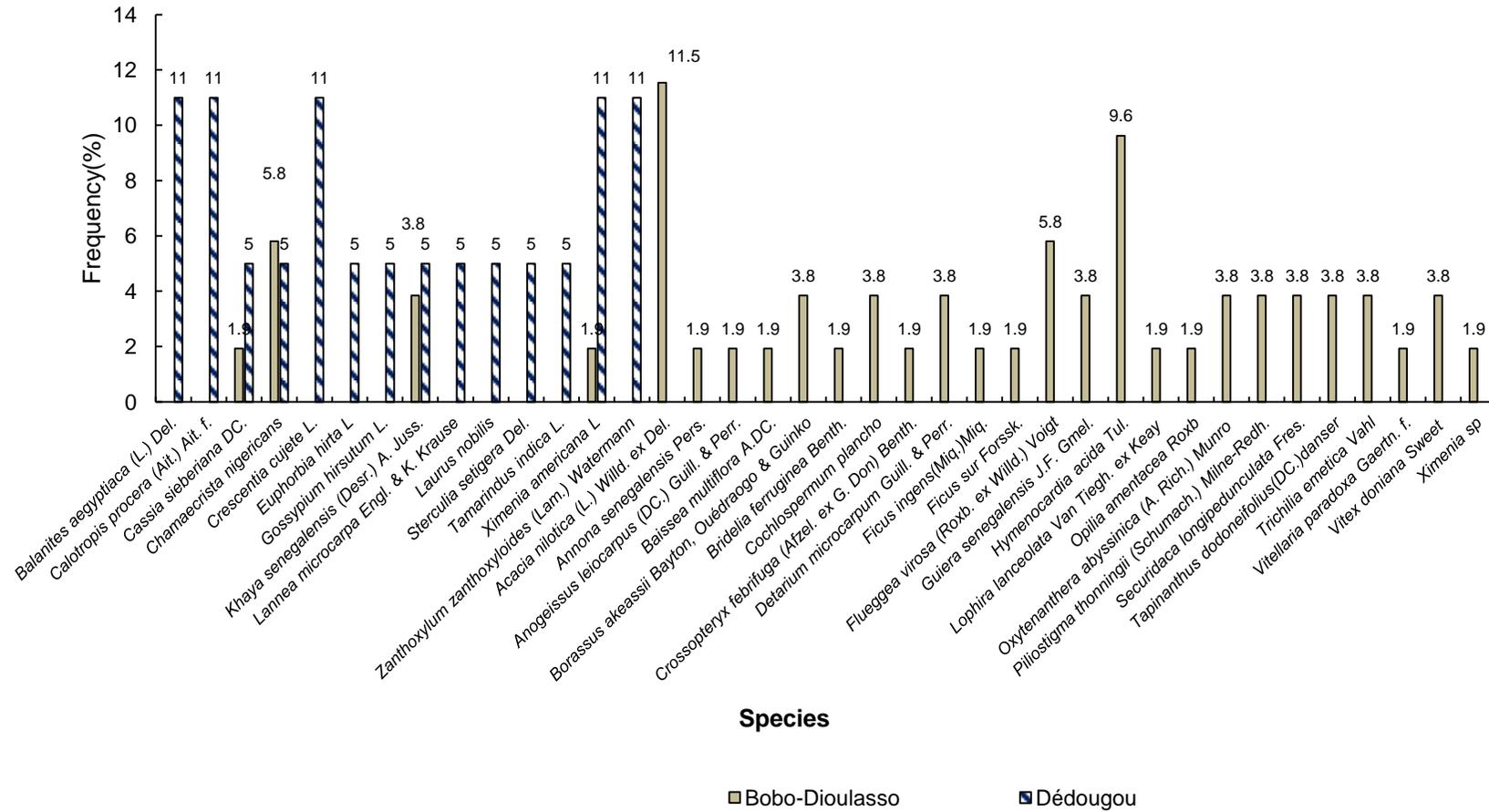


Fig. 2. The distribution of the species of the two cities

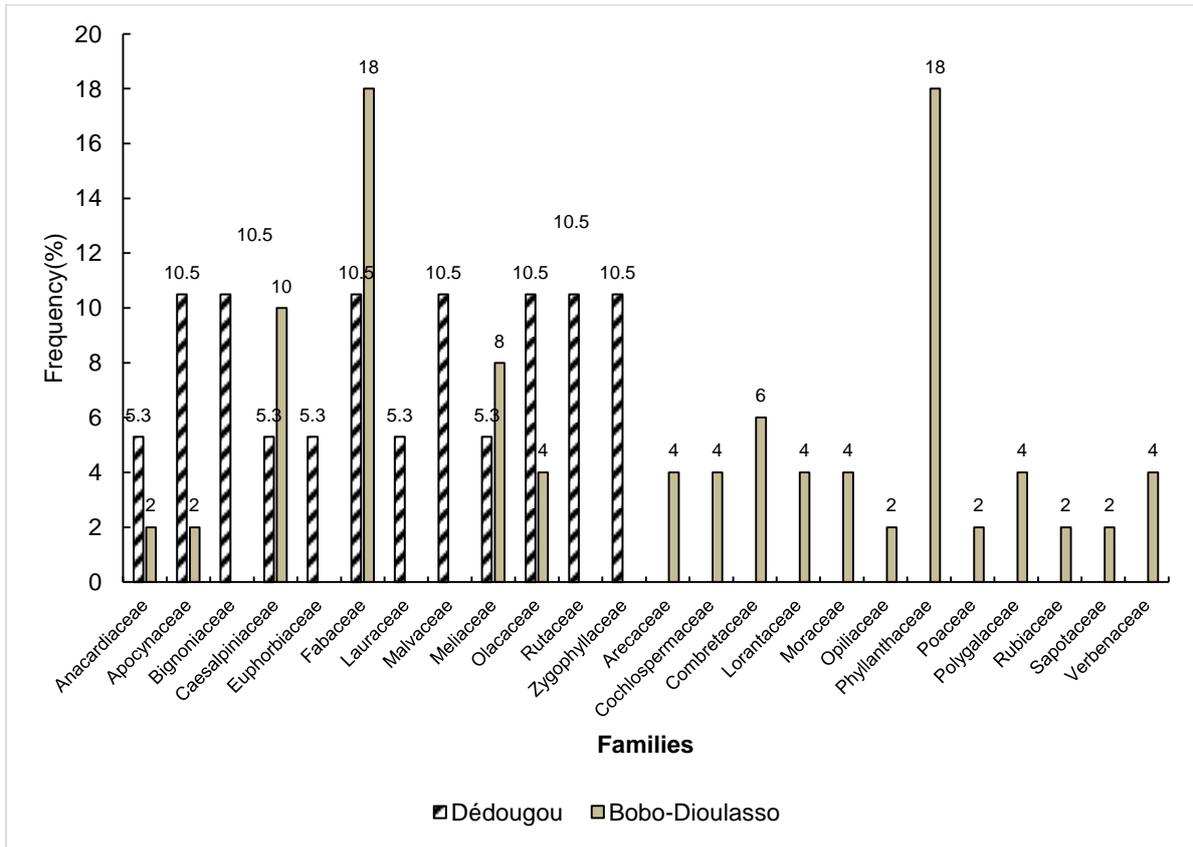


Fig. 3. Distribution according to families

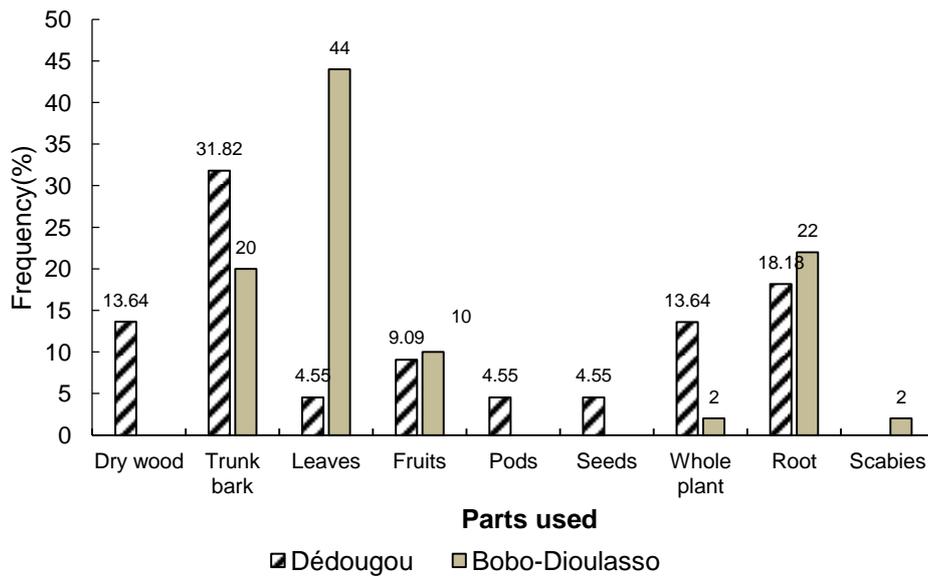


Fig. 4. Parts used in traditional medicine

### 3.1.6 Distribution of medicinal plants according to the mode of administration

Several modes of administration are used by traditional healers in the treatment of candidiasis.

Thus, the most cited mode of administration in Bobo-Dioulasso is the bath associated with intimate toilet with a frequency of 80% and in Dédougou, the method of massage and that of the beverage added to intimate toilet occupy the

first place. with a frequency of 35% each (Fig. 6). Studies by Lema et al. [31] on the recipes of medicinal plants used in the management of ulcers in Burkina Faso on an entity of 290 traditional healers showed that administration by the method of drink (47%) and bath (28%) were the modes the most used. This could be due to the simplicity of these different methods.

### 3.2 Phytochemical Study

#### 3.2.1 Extraction yield

The highest yield was obtained with the hydroethanolic extract of *A. nilotica* fruits (60.33%) and the lowest yield with the ethanolic

extract (48%). Our results are different from those of Doumbia et al. [37] in Mali who used the same organs but an infusion and obtained a yield of 37.15%. This difference could be explained by the extraction technique used.

#### 3.2.2 Characterization of chemical groups

Characterization tests in tubes revealed the presence of tannins, alkaloids, flavonoids and saponosides in both types of *A. nilotica* fruit extracts (Table 1). These results corroborate the work of Ali et al. [17] who had also reported the presence of polyphenols, tannins and alkaloids in the extracts of the study plant.

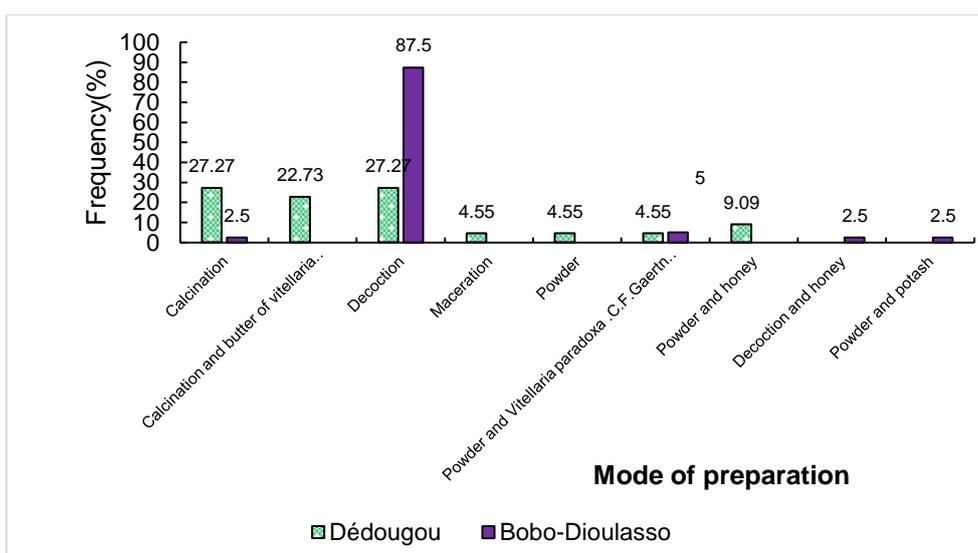


Fig. 5. Breakdown by method of preparation

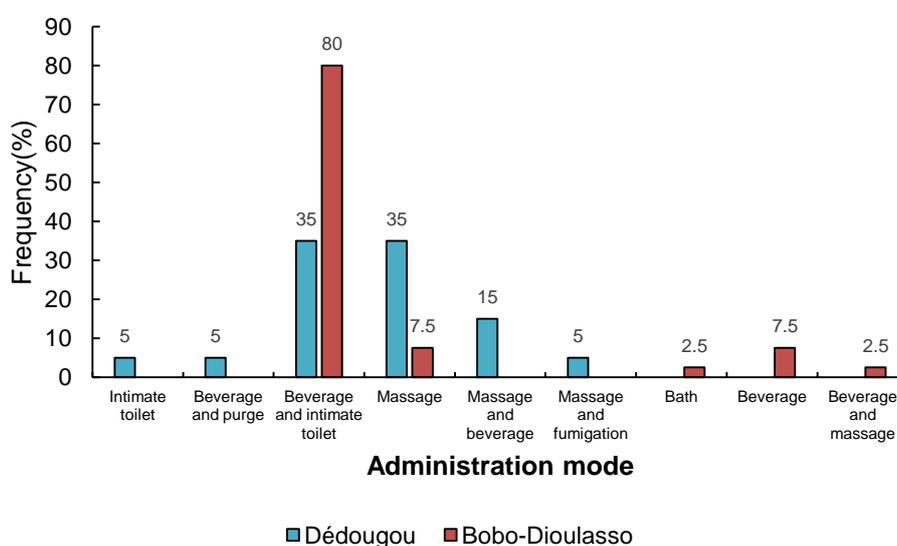


Fig. 6. Distribution according to mode of administration

**Table 1. Characterization tests for chemical groups**

Extracts	Tannins	Chemical groups		
		Flavonoids	Alkaloids	Saponosides
Ethanolic	+	+	+	+
Hydroethanolic	+	+	+	+

Legend: + presence

**3.2.3 Quantification of polyphenolic compounds**

The total phenolic, flavonoids and tannin of ethanolic and the hydroethanolic extract are summary in table (Table 2).

Dosage of total phenolics: The total phenolic contents were  $76.62 \pm 7.23$  and  $80.26 \pm 20.271$  mg EAG/10 mg of dry extract respectively for the ethanolic and the hydroethanolic extract. We find that the total phenolic contents of the two extracts are equivalent. Our results are different from those of Doumbia et al. [37] who obtained  $182.59 \pm 1.41$  (mg EAG/g) of total phenolics with infused fruits of *Acacia nilotica*. This difference in results could be explained by the nature of the extracts extraction method.

Assay of total flavonoids: The dosage of total flavonoids revealed that the content of hydroethanolic extracts was  $0.23 \pm 0.012$  mg EQ/10 mg of extract and ethanolic was  $0.274 \pm 0.09$  mg EQ/10 mg of extract. Our results are different from those of Doumbia et al. [37] who obtained  $9.49 \pm 0.66$  (mg EQ/g) in total flavonoids with *Acacia nilotica* fruit infused.

Tannin content: The tannin contents of the two extracts were  $4.43 \pm 2.13$  and  $73.31 \pm 4.65$  mg EC/10 mg of extract respectively for the ethanolic and the hydroethanolic extract. Studies by Metowogo et al. [38] in Togo on hydro ethanolic extracts obtained  $12.8 \pm 1.3$  mg EC/g of extract.

What is different from ours, the difference could be due to the extraction technique.

**3.3 Biological Activities**

**3.3.1 Evaluation of antioxidant activity**

The antioxidant activities were evaluated by two methods (DPPH and FRAP). With regard to these methods, the percentages of inhibition of DPPH were  $76.33 \pm 0.099\%$  and  $85.59 \pm 0.001\%$  respectively for the ethanolic and hydroethanolic extract and the reducing power (FRAP) of the extracts was of  $3.97 \pm 0.23$  and  $6.22 \pm 0.09$  mmolEAA/10 mg of extract respectively for the ethanolic and hydroethanolic extract (Table 3). Furthermore, studies conducted by Mansouri et al. [39] on the antioxidant activities (DPPH and FRAP) on the species in Morocco against inflammations with the aqueous extract of the gum and found respectively  $0.04 \pm 0.00$  and  $0.013 \pm 0.006$  Mm Equivalent Trolox/g of plant. Rather et al. [16], on methanolic extracts of the flowers and pods of *Acacia nilotica* showed that in terms of antioxidant activity by the DPPH method, the plant has an inhibition rate of 65.86% for the methanolic extract of flowers and 63.86% for the extract of the pods for a concentration of 100 mg/ml. These methods led to the conclusion that the species have an interesting antioxidant activity which could be due to the contribution of either phenolics and/or flavonoids in the recipe.

**Table 2. Total polyphenols assay results**

species	Extracts	Phenolics (mg EAG/10 mg)	Flavonoids (mg EQ/10 mg)	Tannins (mg EC/10 mg)
<i>Acacia nilotica</i> L.	Ethanolic	$76.63 \pm 7.23^b$	$0.23 \pm 0.018^b$	$4.44 \pm 2.13^b$
	Hydroethanolic	$80.27 \pm 20.27^a$	$0.274 \pm 0.01^a$	$73.31 \pm 4.65^a$

Mean values (n=3) ±SD, letters in columns are significantly different (P<0.05)

**Table 3. Table representing the results of the antioxidant activities**

Specie	Extracts	DPPH (%)	FRAP (mmolEAA/10 mg)
<i>Acacia nilotica</i> L.	ethanolic	$76.33 \pm 0.099^b$	$3.97 \pm 0.23^b$
	hydroethanolic	$85.59 \pm 0.001^a$	$6.22 \pm 0.09^a$

Mean values (n=3) ±SD, letters in columns are significantly different (P<0.05)

Table 4. Results of the antibacterial activity

Type of extracts	Strains	Strain names	MIC (mg/ml)	MBC (mg/ml)	Report MBC /MIC	Number of colonies	Genotype
<b>AnF<sub>1</sub> 100%</b>	Uc 2704	<i>Escherichia coli</i>	3.125 <sup>b</sup>	12.5 <sup>c</sup>	4 <sup>h</sup>	2	
	Sc 1148	<i>Salmonella sp</i>	6.25 <sup>a</sup>	50 <sup>a</sup>	8 <sup>f</sup>	1	
	Uc 982	<i>P. aeruginosa</i>	0.781 <sup>d</sup>	50 <sup>a</sup>	64.02 <sup>a</sup>	ND	SHV
	Uc 2525	<i>Citrobacter freundii</i>	3.125 <sup>b</sup>	50 <sup>a</sup>	16 <sup>d</sup>	5	
	Uc 2532	<i>Acinobacter Baumannii</i>	0.781 <sup>d</sup>	50 <sup>a</sup>	64.02 <sup>a</sup>	2	
	273H	<i>Klbesiella pneumoniae</i>	1.563 <sup>c</sup>	25 <sup>b</sup>	15.99 <sup>e</sup>	3	CTM-X15
	Uc 176	<i>Salmonella Typhi</i>	1.563 <sup>c</sup>	12.5 <sup>c</sup>	7.99 <sup>g</sup>	4	
	Sc 1264	<i>shigella.sonnei</i>	0.781 <sup>d</sup>	25 <sup>b</sup>	32.01 <sup>b</sup>	3	
	Uc 2457	<i>Escherichia coli</i>	0.781 <sup>d</sup>	50 <sup>a</sup>	64.02 <sup>a</sup>	5	CTM-X15
	Uc 2455	<i>Escherichia coli</i>	0.781 <sup>d</sup>	50 <sup>a</sup>	64.02 <sup>a</sup>	2	
	565P	<i>Escherichia coli</i>	1.563 <sup>c</sup>	25 <sup>b</sup>	15.99 <sup>e</sup>	1	CTM-X15
	Uc 241	<i>Escherichia coli</i>	1.563 <sup>c</sup>	3.125 <sup>d</sup>	2 <sup>i</sup>	1	CTM-X15
	Uc 763	<i>P. aeruginosa</i>	3.125 <sup>b</sup>	25 <sup>b</sup>	8 <sup>f</sup>	3	CTM-X15
	Uc 714	<i>Escherichia coli</i>	3.125 <sup>b</sup>	3.125 <sup>d</sup>	1 <sup>j</sup>	2	CTM-X15
	Uc 681	<i>Klbesiella pneumonia</i>	1.563 <sup>c</sup>	6.25 <sup>b</sup>	4 <sup>h</sup>	3	CTM-X15
	Uc 1028	<i>Citrobacter sp</i>	3.125 <sup>b</sup>	25 <sup>b</sup>	8 <sup>f</sup>	1	CTM-X15
	Uc 2582	<i>klebsiella pneumoniae</i>	3.125 <sup>b</sup>	25 <sup>b</sup>	8 <sup>f</sup>	3	
Uc 2527	<i>Klbesiella pneumoniae</i>	3.125 <sup>b</sup>	12.5 <sup>c</sup>	4 <sup>h</sup>	2		
<b>AnF<sub>1</sub> 20%</b>	Uc 2704	<i>Escherichia coli</i>	0.781 <sup>d</sup>	25 <sup>b</sup>	32.01 <sup>b</sup>	3	
	Sc 1148	<i>Salmonella sp</i>	3.125 <sup>b</sup>	50 <sup>a</sup>	16 <sup>d</sup>	2	
	Uc 982	<i>P. aeruginosa</i>	1.563 <sup>c</sup>	50 <sup>a</sup>	31.99 <sup>c</sup>	ND	SHV
	Uc 2525	<i>Citrobacter freundii</i>	6.25 <sup>a</sup>	12.5 <sup>c</sup>	2 <sup>i</sup>	3	
	Uc 2532	<i>Acinobacter Baumannii</i>	0.781 <sup>d</sup>	6.25 <sup>b</sup>	8 <sup>f</sup>	5	
	273H	<i>Klbesiella pneumoniae</i>	1.563 <sup>c</sup>	50 <sup>a</sup>	31.99 <sup>c</sup>	1	CTM-X15
	Uc 176	<i>Salmonella Typhi</i>	3.125 <sup>b</sup>	12.5 <sup>c</sup>	4 <sup>h</sup>	2	
	Sc 1264	<i>shigella.sonnei</i>	1.563 <sup>c</sup>	12.5 <sup>c</sup>	7.99 <sup>g</sup>	4	
	Uc 2457	<i>Escherichia coli</i>	1.563 <sup>c</sup>	12.5 <sup>c</sup>	7.99 <sup>g</sup>	3	
	Uc 2455	<i>Escherichia coli</i>	1.563 <sup>c</sup>	12.5 <sup>c</sup>	7.99 <sup>g</sup>	3	
	565P	<i>Escherichia coli</i>	3.125 <sup>b</sup>	3.125 <sup>d</sup>	1 <sup>j</sup>	5	CTM-X15
	Uc 241	<i>Escherichia coli</i>	3.125 <sup>b</sup>	50 <sup>a</sup>	16 <sup>d</sup>	2	CTM-X15
	Uc 763	<i>P. aeruginosa</i>	3.125 <sup>b</sup>	12.5 <sup>c</sup>	4 <sup>h</sup>	4	CTM-X15

Type of extracts	Strains	Strain names	MIC (mg/ml)	MBC (mg/ml)	Report MBC /MIC	Number of colonies	Genotype
	Uc 714	<i>Escherichia coli</i>	3.125 <sup>b</sup>	25 <sup>b</sup>	8 <sup>f</sup>	1	CTM-X15
	Uc 681	<i>Klbesiella pneumonia</i>	1.563 <sup>c</sup>	25 <sup>b</sup>	15.99 <sup>e</sup>	1	CTM-X15
	Uc 1028	<i>Citrobacter sp</i>	3.125 <sup>b</sup>	12.5 <sup>c</sup>	4 <sup>h</sup>	2	CTM-X15
	Uc 2582	<i>klebsiella pneumoniae</i>	3.125 <sup>b</sup>	50 <sup>a</sup>	16 <sup>d</sup>	1	
	Uc 2527	<i>Klbesiella pneumoniae</i>	3.125 <sup>b</sup>	50 <sup>a</sup>	16 <sup>d</sup>	1	CTM-X15

Mean values (n=3) ±SD, different letters in columns are significantly different (P<0.05). Sc:Stool culture; Uc: Urine culture  
AnF<sub>1</sub>100%: Ethanolic extract; AnF<sub>1</sub> 20%: Hydroethanolic extract

### 3.3.2 Determination of minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC)

#### 3.3.2.1 Determination of minimum inhibitory concentration (MIC)

The minimum inhibitory concentration (MIC) represents the smallest concentration that can inhibit the growth of microorganisms by 99.99%. The MIC was observed from the first well to the 7th well depending on the types of microbial strains. Thus, these MICs carried out on the different strains with the ethanolic and hydroethanolic extracts all presented interesting results. In general, the MICs varied from 0.781 mg/ml to 6.25 mg/ml (Table 4). The 100% AnF<sub>1</sub> extract was very active on strains of *Acinobacter baumannii*, *Shigella sonnei*, *P. aeruginosa*, certain *Escherichia coli* with a concentration of 0.781 mg/ml and the 20% AnF<sub>1</sub> extract was very active on *Acinobacter baumannii* and a single strain of *E. coli* at a concentration of 0.781 mg/ml. According to the work of Bashige-

Chiribagula et al. [40], the antibacterial activity of plant extracts can be strong, moderate or weak. Several previous works such as Ali et al. [17] and Banso, [41] had already established the antibacterial properties of *Acacia nilotica* by linking them to the presence of certain bioactive groups including tannins, flavonoids, alkaloids. The same is true for Guta et al in [42] who obtained a powerful antibacterial activity with the ethyl acetate fraction of *Acacia nilotica* fruits with a concentration of 0.25 mg/ml. We can admit that the inhibition of microbial growth could be linked to the presence of flavonoids and tannins in our fruit extracts. This antibacterial activity can be explained by the fact that these metabolites disrupt the stability of the cell membrane, as well as by increasing its permeability [43].

#### 3.3.2.2 Determination of the minimum bactericidal concentration (MBC)

On all bacterial strains, the extracts showed bactericidal activity, except on *P.aeruginosa* harboring the SHV type bla gene which showed

**Table 5. Results of antifungal susceptibility of strains**

Type of extracts	N° of <i>Candida albicans</i> strains	Sensitivity: Diameter (mm) in superscript
AnF <sub>1</sub> 20%	Sc 1228	T <sup>9</sup> , NY <sup>12</sup> , D <sub>1</sub> <sup>14</sup> , D <sub>2</sub> <sup>13</sup> , D <sub>3</sub> <sup>13</sup>
	Sc 1170	T <sup>6</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>34</sup> , D <sub>2</sub> <sup>14</sup> , D <sub>3</sub> <sup>12</sup>
	Vs 301	T <sup>13</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>17</sup> , D <sub>2</sub> <sup>16</sup> , D <sub>3</sub> <sup>13</sup>
	Vs 324	T <sup>6</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>44</sup> , D <sub>2</sub> <sup>27</sup> , D <sub>3</sub> <sup>10</sup>
	Vs 339	T <sup>8</sup> , NY <sup>12</sup> , D <sub>1</sub> <sup>12</sup> , D <sub>2</sub> <sup>12</sup> , D <sub>3</sub> <sup>11</sup>
	Sc 1164	T <sup>10</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>23</sup> , D <sub>2</sub> <sup>17</sup> , D <sub>3</sub> <sup>13</sup>
	Vs 302	T <sup>14</sup> , NY <sup>26</sup> , D <sub>1</sub> <sup>52</sup> , D <sub>2</sub> <sup>14</sup> , D <sub>3</sub> <sup>12</sup>
	Sc 1229	T <sup>11</sup> , NY <sup>24</sup> , D <sub>1</sub> <sup>13</sup> , D <sub>2</sub> <sup>12</sup> , D <sub>3</sub> <sup>8</sup>
	Vs 319	T <sup>12</sup> , NY <sup>23</sup> , D <sub>1</sub> <sup>48</sup> , D <sub>2</sub> <sup>22</sup> , D <sub>3</sub> <sup>16</sup>
	P 235	T <sup>12</sup> , NY <sup>22</sup> , D <sub>1</sub> <sup>32</sup> , D <sub>2</sub> <sup>25</sup> , D <sub>3</sub> <sup>21</sup>
	Vs 310	T <sup>8</sup> , NY <sup>30</sup> , D <sub>1</sub> <sup>52</sup> , D <sub>2</sub> <sup>14</sup> , D <sub>3</sub> <sup>10</sup>
	Vs 297	T <sup>12</sup> , NY <sup>21</sup> , D <sub>1</sub> <sup>30</sup> , D <sub>2</sub> <sup>17</sup> , D <sub>3</sub> <sup>13</sup>
	Vs 338	T <sup>12</sup> , NY <sup>22</sup> , D <sub>1</sub> <sup>54</sup> , D <sub>2</sub> <sup>28</sup> , D <sub>3</sub> <sup>16</sup>
	AnF <sub>1</sub> 100%	Sc 1228
Sc 1170		T <sup>6</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>28</sup> , D <sub>2</sub> <sup>25</sup> , D <sub>3</sub> <sup>18</sup>
Vs 301		T <sup>13</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>22</sup> , D <sub>2</sub> <sup>19</sup> , D <sub>3</sub> <sup>17</sup>
Vs 324		T <sup>6</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>26</sup> , D <sub>2</sub> <sup>18</sup> , D <sub>3</sub> <sup>12</sup>
Vs 339		T <sup>8</sup> , NY <sup>12</sup> , D <sub>1</sub> <sup>17</sup> , D <sub>2</sub> <sup>15</sup> , D <sub>3</sub> <sup>13</sup>
Sc 1164		T <sup>10</sup> , NY <sup>6</sup> , D <sub>1</sub> <sup>20</sup> , D <sub>2</sub> <sup>17</sup> , D <sub>3</sub> <sup>13</sup>
Vs 302		T <sup>14</sup> , NY <sup>26</sup> , D <sub>1</sub> <sup>26</sup> , D <sub>2</sub> <sup>15</sup> , D <sub>3</sub> <sup>10</sup>
Sc 1229		T <sup>11</sup> , NY <sup>24</sup> , D <sub>1</sub> <sup>18</sup> , D <sub>2</sub> <sup>13</sup> , D <sub>3</sub> <sup>10</sup>
Vs 319		T <sup>12</sup> , NY <sup>23</sup> , D <sub>1</sub> <sup>38</sup> , D <sub>2</sub> <sup>20</sup> , D <sub>3</sub> <sup>16</sup>
P 235		T <sup>12</sup> , NY <sup>22</sup> , D <sub>1</sub> <sup>48</sup> , D <sub>2</sub> <sup>25</sup> , D <sub>3</sub> <sup>14</sup>
Vs 310		T <sup>8</sup> , NY <sup>30</sup> , D <sub>1</sub> <sup>32</sup> , D <sub>2</sub> <sup>24</sup> , D <sub>3</sub> <sup>16</sup>
Vs 297		T <sup>12</sup> , NY <sup>21</sup> , D <sub>1</sub> <sup>50</sup> , D <sub>2</sub> <sup>15</sup> , D <sub>3</sub> <sup>13</sup>
Vs 338		T <sup>12</sup> , NY <sup>22</sup> , D <sub>1</sub> <sup>54</sup> , D <sub>2</sub> <sup>28</sup> , D <sub>3</sub> <sup>16</sup>

Negative control T=80% ethanol; D<sub>1</sub>= disc 1 (50 mg/ml(extracts)); D<sub>2</sub>=disc 2 (25 mg/ml(extracts)); D<sub>3</sub>= disc 3(12.5 mg/ml(extracts)); NY=nystatin (conventional antibiotic)  
 Sc: Stool culture; Uc: Urine culture; Vs: Vaginal samples; P: Pus  
 ANF<sub>1</sub>100%: Ethanolic extract; ANF<sub>1</sub>20%: Hydroethanolic extract

countless colonies on agar medium. The best minimum bactericidal concentration (MBC) was 3.123 mg/ml (Table 4). Gouffi and Mabrouk. [43] performed MBC on strains of *Escherichia coli* ATCC 25922 En. cloacae, *R. ornithinolytica*, *Klbesiella pneumoniae*, ESBL-producing *Escherichia coli* and obtained positive results from a concentration of *Laurus nobilis* essential oil of 05 µl/ml; 2.5 µl/ml and 1.25 µl/ml. The MBC/MIC ratio makes it possible to determine whether an extract is bactericidal or bacteriostatic. According to Okou et al. [44], if the MBC /MIC ratio  $\leq 4$ , the tested substance is bactericidal and if the MBC/MIC ratio  $> 4$ , the tested substance is bacteriostatic. The 100% AnF<sub>1</sub> extract is bactericidal on 5 strains of Enterobacteriaceae and bacteriostatic on the other 13 strains of Enterobacteriaceae. Also, the AnF<sub>1</sub> 20% extract is bactericidal on 5 strains of Enterobacteriaceae and bacteriostatic on the other 13 strains of Enterobacteriaceae. The bactericidal and bacteriostatic activity of our extracts could also be due to the presence of secondary metabolites, in particular phenolics and/or flavonoids.

### 3.3.2.3 Antifungal susceptibility test of *Acacia nilotica* extracts

All the strains of *Candida albicans* isolated (13 strains in total) were the subject of a sensitivity study to extracts of *Acacia nilotica* in vitro. We note that some strains showed resistance to nystatin. In addition, the control considered negative (80% ethanol) showed resistance and/or sensitivity depending on the strain considered. Also, all ethanolic extracts showed antifungal activity on most of our *Candida albicans* strains tested. It appears that the diameters of inhibition varied from 6 to 14 and 6 to 30 mm respectively for the negative control and the positive control. With regard to the hydro ethanolic extract, the diameters varied from 12 to 54; 12 to 27 and 8 to 16 mm respectively for disc 1, 2 and 3. Similarly, the inhibition diameters of the ethanolic extract varied from 17 to 54; 13 to 28 and 12 to 28 mm respectively for disk 1, 2 and 3 (Table 5). By comparing the discs of our extracts to the references, we note that our extracts have the best inhibition diameters. These results could explain the use of *Acacia nilotica* in the treatment of candidiasis.

## 4. CONCLUSION

The investigations made it possible to question 52 traditional healers and to identify 38 medicinal plants distributed in 25 botanical families. The

study revealed that the majority of respondents are men (75%) in each city. The best contents of total phenolic compounds were given by the hydroethanolic extract; i.e.,  $80.27 \pm 20.27$  mg GAE/10 mg. Similarly, the best values for total flavonoids were obtained from  $0.274 \pm 0.01$  mg QE / 10 mg extract and that of tannins were  $73.31 \pm 4.65$  mg EC / 10 mg extract. Regarding the anti-DPPH• and anti-FRAP activities, the best were  $85.59 \pm 0.001\%$  and  $6.22 \pm 0.09$  mmolEAA/10 mg. According to the frequency of citation, *Acacia nilotica* was the species most used in the treatment of vaginal candidiasis. the most represented families were the Fabaceae (18%) and the Phyllantaceae (18%). The mode of preparation and the parts used were the decoction respectively (87.5%: Bobo-Dioulasso and 27.27%: Dédougou), the leaves (44% Bobo-Dioulasso) and the bark of the trunk (31.82% Dédougou). Interesting results were obtained in terms of antimicrobial activity, with the best values of MIC and MBC respectively. of 0.781 and 3.125 mg/ml. In addition, the extracts possess strong inhibitory activity on *Candida albicans* strains with large diameters up to 54 mm. It would be more interesting to deepen the investigations on this recipe of medicinal plants which has a strong activity on the microbial stocks in order to propose the most effective treatment without risk of toxicity for the man.

## ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

- Chassota F, Negrib MFN, Svidzinskib AE, Donattic L, Peraltad RM, Svidzinskib TIE. Can intrauterine contraceptive devices be a reservoir of *Candida albicans*? *Contraception*. 2008;(77):355–359. DOI: 10.1016/j.contraception.2008.01.007
- Fanou BA, Klotoe JR, Dougnon V, Monteiro A, Koudokpon CH, Loko F. Prevalence and factors associated with vulvovaginal candidiasis in women admitted for consultation at the Mènontin Zone Hospital (Bénin). *Pan African Medical Journal*. 2022;42(215). DOI:10.11604/pamj.2022.42.215.28984
- Bamba S, Zida A, Sangaré I, Cissé M, Denning DW, Hennequin C. Burden of Severe Fungal Infections in Burkina Faso. *Journal of Fungi (Basel, Switzerland)*. 2018;4, 35. DOI: 10.3390/jof4010035
- WHO. who-releases-first-ever-list-of-health-threatening-fungi; 2022. Available: <https://www.who.int/fr/news/item/25-10-2022->.
- Camara D, Bene K, Gnahoue G, Fofie NBY, Zirihi NG. Ethnobotanical study, Evaluation of antifungal activity on *Candida albicans* and toxicity on HFF cells of *Bersama abyssinica* (Fresen.), a plant from the Ivorian pharmacopoeia. *European Scientific Journal*. 2016;12(3):1857-7431. DOI: 10.19044/esj.2016.v12n3p171
- Sylla K, Sow D, Lakhe NA, Tine RC, Dia M, Lelo S, et al. Vulvovaginal candidiasis in the Parasitology-Mycology laboratory of the University Hospital Center of Fann, Dakar (Sénégal). *Rev. Cames Sante*. 2017;5(2):2424-7243.
- Doumbo SN, Dara NJ, Bamadio A, Zeguime A, Diarra N, Garango A, et al. Epidemiological and etiological profile of vulvovaginal candidiasis in women in consultation in the gynecology-obstetrics department, chu gabriel toure, bamako - mali. *Mali Medical*. 2022;37(3):35-39.
- Yordanov M, Dimitrova P, Patkar S, Saso L, Ivanovska N. Inhibition of *Candida albicans* extracellular enzyme activity by selected natural substances and their application in *Candida* infection. *Can. J. Microbiol*. 2008;54:435–440. DOI: 10.1139/W08-029
- DeRosa FG, Garazzino S, Pasero D, DI Perri G, Ranieri VM. Invasive candidiasis and candidemia: New recommendations. *Minerva Anesthesiol*. 2009;75(7-8):453-8.
- Djohan V, Angora KE, Vanga-Bosson AH, Konaté A, Kassi FK, Yavo W and al. In vitro sensitivity of *Candida albicans* strains of vaginal origin to antifungals in Abidjan (Ivory Coast). *Journal of Medical Mycology*. 2012;22:129-133. DOI: 10.1016/j.mycmed.2011.11.005
- Agre DJ. Evaluation and optimization tests of the antifungal activity of bark extracts of *Eucalyptus torelliana* F. Muell. (Myrtaceae) on the in vitro growth of *Candida albicans*, *Candida glabrata*, *Candida tropicalis*. Doctor's thesis. 2015;188.
- Dali A, Sid Mohand A. The frequency of trichomoniasis and genital candidiasis among women consulting at gynecology services in the Tizi-Ouzou region. Master Memory; 2016.
- Cardinale V. Recurrent vaginal candidiasis due to *Candida albicans*. Doctor of Pharmacy thesis. 2001;155.
- Kechia FA, Dohbit JS, Kouotou EA, Iwewe SY, Dzoyem JP, Mbopuouo NM, and al. Epidemiological and Etiological Profile of Vulvovaginal Candidiasis in Pregnant Women in Yaoundé (Cameroun). *Health Sci. Dis*: 2015;16(4). Available: [www.hsd-fmsb.org](http://www.hsd-fmsb.org)
- WHO (World Health Organization). Monographs on Selected Medicinal Plants. 2002;2:300-316.
- Rather LJ, Shahid-ul-Islam, Faqeer M. *Acacia nilotica* (L.): A review of its traditional uses, phytochemistry, and pharmacology. *Sustainable Chemistry and Pharmacy*. 2015;2352-5541. Available: <http://dx.doi.org/10.1016/j.scp.2015.08.002>
- Ali A, Akhtar N, Khan BA, Khan MS, Rasul A, Zaman SUZ and al. *Acacia nilotica*: A plant with multiple medicinal uses. *Medicinal Plant Research Journal*. 2012;6(9):1492-1496. DOI: 10.5897/JMPR11.1275 ISSN 1996-0875
- Nguemo Dongock D, Laohudumaye Bonyo A, Mapongmestem PM, Bayegone E. Ethnobotanical and phytochemical study of medicinal plants used in the treatment of cardiovascular diseases in Moundou (Chad). *International Journal of Biological and Chemical Sciences*. 2018;12(1):203-216. DOI: <https://dx.doi.org/10.4314/ijbcs.v12i1.16>

19. Evenamede KS, Kpegba K, Simalou O, Boyode P, Agbonon A, Gbeassor M. Comparative study of the antioxidant activities of ethanolic extracts of leaves, barks and roots of *Cassia sieberiana*. International Journal of Biological and Chemical Sciences. 2017;11(6):2924-2935.  
DOI:  
<https://dx.doi.org/10.4314/ijbcs.v11i6.29>
20. Nga EN, Yinyang J, Baran à Bidias E, Etame-Loe G, Dibong SD. Phytochemical and pharmacological study of *Alchornea cordifolia* (Schum. & Thonn.) Mull. Arg. and *Mangifera indica* in the traditional treatment of hemorrhoidal disease. Journal of Applied Biosciences. 2017;109:10649-10661.  
Available:<http://dx.doi.org/10.4314/jab.v109i1.9>
21. Singleton VL, Orthofer R, Lamuela-Raventos RM. Analysis of total phenols and other oxidation substrates and antioxidants using Folin Ciocalteu's reagent, Methods Enzymol. 1999;299:152-178.
22. Arvouet-Grand A, Vennat B, Pourrat A, Legret P. Standardization of a propolis extract and identification of the main constituents, Belgian Pharmacy Journal. 1994;49:462-468.
23. Reference method for the determination of tannins. Official Journal of the European Communities.1984;197:18-20.
24. Velazquez E, Tournier HA, Buschiazzo PM, Saavedra G, Schinella. Antioxidant activity of plant extracts from Paraguay, Fitoterapia. 2003;74:91-97.
25. Dieng SIM, Fall AD, Badji KD, Sarr A, Sene M, Mbaye A, and al. Evaluation of the antioxidant activity of hydro-ethanolic extracts of the leaves and barks of *Piliostigma thonningii* Schumach. International Journal of Biological and Chemical Sciences. 2017;11(2):768-776.  
DOI:  
<https://dx.doi.org/10.4314/ijbcs.v11i2.19>
26. Arias ME, Gomez JD, Cudmani NM, Vattuone MA, Isla MI. Antibacterial activity of ethanolic and aqueous extracts of *Acacia aroma* Gill. ex-Hook et Arn, Life Sciences. 2004;75:191-202.
27. Bashige VC, Bakari AS, Okusa PN, Kalonda EM, Lumbu JBS. Phytochemical screening and antimicrobial activity of six edible rhizomes used in traditional medicine in Lubumbashi (RDC). International Journal of Biological and Chemical Sciences. 2020;14(4):1367-1380.  
DOI: <https://doi.org/10.4314/ijbcs.v14i4.16>
28. Traoré A, Derme AI, Sanon S, Gansane A, Ouattara Y, Nebié I and al. Ethnobotanical knowledge and phytotherapeutic practices of traditional healers of Comoé for the treatment of malaria: process of scientific research of new antimalarials in Burkina Faso. Special File: Traditional Medicine in Africa, Ethnopharmacologia. 2009;(43).
29. Guinnin FDF, Sacramento TI, Sezan A, Ategbro JM. Ethnobotanic study of medicinal plants used in the traditional treatment of viral hepatitis B and C in some departments of Benin. International Journal of Biological and Chemical Sciences. 2015;9(3):1354-1366.  
DOI: <http://dx.doi.org/10.4314/ijbcs.v9i3.20>
30. Sawadogo M, Bangou MJ, Dakio B, Lema A, Thiombiano HM, Ouoba B. Ethnobotanical survey on medicinal plants (*Carica papaya* L. and *Agelanthus dodoneifolius* (DC.) Polhill & Wiens) used in the treatment of Hepatitis in Burkina Faso, phytochemistry and antioxidant activity. World Journal of Advanced Pharmaceutical and Life Sciences. 2021;01(01):024-035.  
DOI: <http://dx.doi.org/10.4314/ijbcs.v9i3.20>
31. Lema A, Bangou MJ, Sawadogo M, Thiombiano HM, Ouoba HY. Recipes of medicinal plants used in the management of peptic ulcers in Burkina Faso: Ethnobotanical study. International Journal of Scientific and Research Archives. 2022;06(01):263–278.  
DOI:  
<https://doi.org/10.30574/ijrsra.2022.6.1.0133>
32. Sawadogo M, Bangou MJ, Lema A, Thiombiano MH, Ouoba HY, Ouoba B. Medicinal plants used in the composition of anti-virals Recipes against hepatitis in Burkina Faso: Ethnobotanical study. European Journal of Pharmaceutical Research. 2022;2(2):2795-8035.  
DOI:  
<http://dx.doi.org/10.24018/ejpharma.2022.2.2.34>
33. Thiombiano MH, Bangou MJ, Ouoba B, Sawadogo M, Lema A, Nacoulma AP and al. Plants and Medicinal Practices in Burkina Faso: The Case of Breast Cancer. Journal of Diseases and Medicinal Plants. 2022;8(3):46-54.  
DOI: 10.11648/j.jdmp.20220803.11

34. Kpodji P, Lozes E, Dougnon V, Assogba P, Koudokpon H, Baba-Moussa L. Use of plants from southern Benin in the treatment of inflammatory diseases: Ethnopharmacological survey among herbalists. *Rev. Ivory. Science. Technology.* 2019;34(127-143):1813-3290.
35. Dakio B, Bangou MJ, Ouoba P, Ouoba YH. Medicinal Plants used in the Treatment of Hepatitis in Bobo-Dioulasso: Studying the Availability and Analyzing the Phytochemical Properties of *Combretum micranthum* G. Don and *Entada Africana*. 2020;1857-7881. DOI: 10.19044/esj.2020.v16n40p1
36. Zerbo P, Millogo-Rasolodimby J, Nacoulma-Ouédraogo OG, Damme PV. Medicinal plants and medical practices in Burkina Faso: Case of the Sanan, woods and forests of the tropics. *Medicinal plants.* 2011;307(1):53.
37. Doumbia S, Fofie YNB, Haidara M, Denou A, Sanogo R. Determination of the contents of chemical constituents and antiradical activities of plant extracts used in the traditional treatment of liver diseases in Mali. *RAMReS Review-Pharm Series. Med. Transl. Afr.* 2021;20(2):80-88.
38. Metowogo K, Darré T, Daubeuf F, Lawson-Evi P, Eklou-Gadegbeku K, Aklikokou KA, et al. Effect of Topical Application of Hydro-Ethanollic Extract of *Acacia nilotica* Pods on Second-Degree Cutaneous Infected Burns. *Journal of Pharmacy and Nutrition Sciences.* 2015;5:24-29.
39. Mansouri LE, Bousta D, Balouiri M, Khanchoufi AE, Rivero-Pérez MD, Gonzalez-Sanjosedé ML, et al. Phytochemical screening, antioxidant and anti-inflammatory properties of *Acacia nilotica* gum from southeastern in Maroc. *International Journal of pharmacology and Clinical Trials.* 2014;(2):2051-8293.
40. Bashige-Chiribagula V, Many-Mboni H, Ntabaza-Ndage V, Numbi Ilunga E, Bakari-Amuri S, Kalonda Mutombo E, et al. Ethnobotany, biological and chemical study of plants used as anti-cariogenic in Lubumbashi-RD Congo. *Phytotherapy;* 2015. DOI: 10.1007/s10298-015-1004-5
41. Bansa A. Phytochemical and antibacterial investigation of bark extracts of *Acacia nilotica*. *Journal of Medicinal Plants Research.* 2009;3(2):082-085. Available:<http://www.academicjournals.org/JMPR>
42. Guta M, Urga K, Assefa A, Lemma H, Addis G, Gameda, et al. Antibacterial activity and acute toxicity study of *Acacia nilotica*. *Ethiop. J. Biol. Sci.* 2007;6(1):43-49.
43. Gouffi Y, Mabrouk A. Inhibitory effect of essential oils of *Laurus nobilis* and *Pimpinella anisum* on enterobacteriaceae producing extended-spectrum  $\beta$ -lactamases (ESBL). *Master Memory;* 2022.
44. Okou OC, Yapo SES, Kporou KE, Baibo GL, Monthaut S, Djaman AJ. Evaluation of the antibacterial activity of *Solanum torvum* Swartz (Solanaceae) leaf extracts on the in vitro growth of 3 strains of enterobacteriaceae. *Journal of Applied Biosciences.* 2018;122:12282-12290. Available:<https://dx.doi.org/10.4314/jab.v12.211.8>

**APPENDIX**

Ethnobotanical survey sheet

N° .....

Date.....

I. Identity of the traditional healer.....

Surmane.....

First name.....

Age.....

Sex.....

Ethnicity : .....

Marital status.....

Level of education : Literate  No literate

Region.....Sector.....

Tel.....

Professional experience : Part-time traditional healers  Full-time traditional healers

Member of an association: No  Yes

If yes, which one ?.....

III. Knowledge about vaginal candidiasis :

Disease	N°	Recipes	Part used	Obtaining	Use
vaginal candidiasis					

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