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Antibacterial Activities of some Medicinal Plants Used for Treatment of Infectious Diseases in the Vina and Mayo-Louti Divisions of Cameroon

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BTT and GZ designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors SPCF, MTF and JRK managed the analyses of the study. Author LNT managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: In Cameroon, most peoples use traditional medicine treating infectious diseases. To verify the scientific bases of these locally used medicinal plants, an ethnobotanical survey was carried out in some villages of Vina and Mayo-Louti Divisions**.**
Materials and Methods: Interviews were conducted through structured questionnaires among 31 traditional healers living in these divisions. With the medicinal plants revealed, a literature investigation on their therapeutic effects, as well as *in vitro* antimicrobial activity of these plants

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were conducted. The agar diffusion method was used to determine the antibacterial activities of the methanol extracts against the pathogens while the Minimum Inhibitory Concentration (MIC) was determined using the Broth dilution method.

Result: A total of 15 medicinal plants species belonging to 12 families are being used in the treatment of numerous infectious diseases in the Vina and Mayo-Louti Divisions. *Khaya senegalensis* (Meliaceae), *Terminalia glaucescens* (Combretaceae), *Flacourtia flavescens* wild (Salicaceae), *Pterocarpus erinaceus* (Fabaceae) and *Boswellia dalzielii* (Burseraceae) were the mostly used plants for the treatment of infectious diseases in the study areas. Maceration (43.75%) was the common mode of preparation, followed by infusion (31.25%) and decoction (25.00%). Bioassay showed that crude methanol extract of *Pterocarpus erinaceus* and *Flacourtia flavescens* were the most active plant extract with a MIC of 0.8 mg/ml on many tested bacteria. The antibacterial activity of *Boswellia dalzeilii* from Cameroon are reported here for the first time.

Conclusion: Many herbals remedies are used in these divisions for the treatment infectious diseases. The plants can be used as source of antibacterial drugs to treat infections caused by susceptible bacteria

Keywords: Antibacterial activities; medicinal plants; infectious diseases; Cameroon.

1. INTRODUCTION

Infectious diseases are one of the leading causes of morbidity and mortality worldwide, especially in developing countries [1]. Indeed, human commensal bacteria could become pathogenic either due to a change in their normal behaviour /habitat or a failure in the immune system [2]. Furthermore, enteric fever caused by *Salmonella enterica* serotypes Typhi and Paratyphi A, B, and C is mainly a disease in developing countries, and it is occasionally diagnosed as an imported disease in countries where the disease is not endemic [3].

The discovery of antibiotics has decreased the spread and severity of a wide variety of infectious diseases. However, as a result of their uncontrolled use, the efficiency of many antibiotics is being threatened by the emergence of microbial resistance to existing chemotherapeutic agents [4] such as direct destruction of antibiotics by penicillinase producing bacteria, or resistance to the wide range use of Amphotericin B and azole derivatives by pathogenic fungi [5].

While bioactive natural compounds have been isolated mainly from cultivable microbial strains, unexploited biologically active metabolites of different sources including plants remain to be investigated [6] to alleviate or help respond to current health care situations.

Plant-derived natural products, therefore, represent an attractive source of antimicrobial agents since they are natural, have manageable side effects and available at affordable prices [7]. Also, plants derived agents may have different mechanisms of action than conventional drugs [8].

The diversity of Cameroon flora has a dominance of plants that have been used so fare for many pharmacological purposes. Although traditional medicine has played and continue to play a critical role worldwide in treating infectious diseases [9]; no scientific work has been carried out to the best of our knowledge, in many parts of the country to index medicinal plants used in these localities for the treatment of infectious diseases. Thus the present proposal, which aims at carrying out an activities of medicinal plants used for the treatment of infectious diseases in some localities of Vina and Mayo-Louti Division (Northern Region of Cameroon).

2. MATERIALS AND METHODS

2.1 Ethnobotanical Survey and Plant Collection

This study took place in Northern Cameroon, and more specifically in the Vina Division (6° 37' 60" latitude North and 13° 24' 0" longitude East) and the Mayo-Louti Division (9° 37' 60" latitude North and 13° 55' 60" longitude East). To identify some plants used for the treatment of infectious diseases such as malaria, typhoid, diarrhoea and dysentery in these regions, an ethnobotanical survey was carried out from April 2013 to November 2013 involving thirty-one traditional healers aged between 20 and 50 years. A questionnaire was used for the survey and it

comprised: types of medication (medicinal plants or pharmaceutical products) used when sick; and for each medicinal plant used, its vernacular name, parts of the plant used, methods of preparation and administration, diseases used for, the solvent used.

The interviews were conducted in the local language (foufouldé) to facilitate communication. Fresh samples of plants were harvested, and their identification confirmed at the Cameroon National Herbarium (CNH), where their full scientific names and voucher number were obtained. Further literature investigations were also conducted relative to their therapeutic and pharmacological effects and their phytochemical composition. The plants of interest in this study should be traditionally used for the treatment of infectious diseases in the Department of Vina and the Department of Mayo-louti and should have been cited by at least five traditional healers in both divisions. After the ethnobotanical survey, *Khaya senegalensis* (Meliaceae), *Terminalia glaucescens* (Combretaceae), *Flacourtia flavescens* wild (Salicaceae), *Pterocarpus erinaceus* (Fabaceae) and *Boswellia dalzielii* (Burseraceae) were selected for antimicrobial analyses.

2.2 Preparation of Extracts

The bark and roots of four of the above plants were harvested in the Vina Division while roots and bark of *Boswellia dalzielii* were harvested in the Mayo-Louti Division, shade-dried, and ground. 500 grams of each powder was macerated in 2000 mL of methanol in an Erlenmeyer flask. The mixture was filtered, and the residue returned to the methanol after every 24 hours. The operation was repeated twice. At the end of the 72 hours, the filtrate was concentrated using a Rotary evaporator.at 45°C. The resulting extract was weight, and the extraction yield was 7.36, 11.28, 8.4, 5.5, 9.82, 3.00 and 4.75 for *Terminalia glauscescens* stem, *Terminalia glauscescens* root, *Khaya senegalensis*, *Pterocarpus erinaceus*, *Boswellia dalzielii* root, *Boswellia dalzielii* stem and *Flacourtia flavescens* respectively. These extracts were then stored in sterile, clean and dry flasks before usage

2.3 Microorganisms

Microorganisms were obtained from the Laboratory of Microbiology and Antimicrobial Substances of the University of Dschang. All the ten microorganisms investigated, were associated with numerous cases of human infections. The bacteria (clinical isolates) used in this study were collected from Centre Pasteur (Yaoundé-Cameroon), and constitute of two Gram-positive bacteria (*Bacillus cereus* and *Staphylococcus aureus*), and eight Gram-negative bacteria (*Escherichia coli*, *Klebsiella pneumonia*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Salmonella typhimurium*, *Salmonella paratyphi* A, *Salmonella paratyphi* B). All the microorganisms were maintained at 4°C on Muller Hinton Agar.

2.4 Phytochemical Screening of Plants Extracts

Phytochemical screening aims to estimate the nature of secondary metabolites responsible for the biological activity of plant extracts. Phytochemical Screening was carried out, according to the methods described by Prashant et al. [10] and Shaheen et al. [11].

2.5 Antibacterial Test

Microbiological screening of the crude extracts was evaluated by the agar diffusion method (agar well diffusion method) as described by Abubakar[12] and Titilope et al. [13]. The Petri dish was incubated overnight at 37°C, and microbial growth was determined by measuring the inhibition zone diameter. The extracts were considered active when the inhibition zone diameter was greater than or equal to 14 mm. For each bacterial strain, controls were done, and pure solvents were used instead of the extract. The experiment was done three times, and the mean values are presented.

2.6 Determination of Minimal Inhibitory Concentration (MIC) and Minimal Bactericidal Concentration (CMB)

The MIC and CMB were determined by the method of micro dilution in a liquid medium [9]. In the 96-well microplates, 100 µL of double concentrated culture broth (MHB) was added to each well. These wells were then supplemented with the various extracts (100 µL) and reference antibiotic (ceftriaxone) concentrations ranging from 12000 to 93.75 µg / mL and from 50 to 0.39 µg / mL respectively. Finally, ten µL of bacteria inoculum 1.5×10^6 CFU/mL were introduced into each well. Control wells containing only the broth and those containing the inoculum without extract or antibiotics were made.

After 24 hours of incubation at 37°C, 20 µL of 2% MTT (Methyl thiazolyl-diphenyl tetrazolium bromide) solution were added in one test wells of each repeated concentration. This compound is instantly metabolized (reduced) by the active living cell mitochondrial succinate dehydrogenase to formazan to form a purple precipitate whose intensity is proportional to the number of living cells and the metabolic activity of each cell. The lowest concentration at which no visible colour change was observed was considered as the MIC. For wells that did not receive a developer, 20 µl of a solution of the wells corresponding to the concentrations that did not display the blue-violet colour were removed and streaked on the surface of the MHA previously poured into Petri dishes. After 24 hours of incubation at 37°C, the concentrations of wells having less than three bacterial colonies were considered bactericidal and the smallest of these, noted as CMB.

2.7 Data Analyses

Descriptive statistic was principally used in this study. Initially, information on the popular uses of the species collected, along with botanical information, was compiled into a database. The species were listed in alphabetical order by scientific name, a popular name in the region (vernacular name), voucher number and frequency of use. The frequency of citation (FC) of the used plant species was evaluated using the following formula:

$$FC = \frac{Number\ of\ times\ a\ particular\ species\ was\ mentioned}{total\ number\ of\ times\ that\ all\ species\ were\ mentioned}$$

Quantitative data were subjected to one-way analysis of variance, and differences between samples at P≤0.05 were determined by Duncan Multiple Range Test using the Statistical Package for the Social Sciences (SPSS) program. The experimental results were expressed (where appropriate) as the mean ± standard deviation of three replicates.

3. RESULTS

3.1 Ethno-Pharmacological Survey and Phytochemical Screening of Extracts

The set of plants recorded during the ethnobotanical survey and their frequency of citation are grouped in Table 1. A total of 15 plants belonging to 12 botanical families were identified. The leaves were the most used parts followed by the bark. The 05 (five) most common plants (cited five times and more) were: *Boswellia dalzielii*, *Pterocarpus erinaceus*, *Khaya senegalensis*, *Flacourtia flavecens* and *Terminalia glaucescens*.

About three of the plants obtained is used to treat at least three others diseases. This is the case of *Khaya senegalensis* (Rheumatoid arthritis, Syphilis, leprosy); *Jatropha curcas* (Hypertension, rheumatism, diabetes); *Euphobia* hirta (Skin diseases, bronchitis and asthma). Three of these plants (*Boswellia dalzielii*, *Flacourtia flavescens* and *Terminalia glaucescens*) presented higher frequencies of citation.

3.2 Demography/Personal Information on Respondents

The characteristics of the population are presented in Figs. 1 to 4. From Fig. 1 it is noted that thirty-one (31) traditional healers were interviewed. The informants were between 20 and 50 years old (Fig. 3), and the modal class was 39 to 49 years old. The age distribution of informants showed that most of the traditional healer encountered during the survey are within the age range 29-49. Among these informants, there were 9 women and 22 men (Fig. 2).

3.3 Parts of the Plant Used, Mode of Preparation

Leaves, roots, stems, whole plant, fruits, seeds and barks were used for numerous preparations. Amount these, the most commonly used plant parts (Fig. 3). were the leaves (40.91%), followed by stems (31.81%), roots (18.18%), fruits (4.55%) and whole plant (4.55%). Water was the only solvent used for different preparations that included maceration (43.75%), infusion (25.25%) and decoction (25.00%) (Fig. 4).

After an investigation, five most used plants caught our attention. They were latter collected and used for biological tests.

3.4 Phytochemical Screening

Plants samples were screened for the following classes of compounds: polyphenols, tannins, terpenes steroids, flavonoids, alkaloids, anthraquinone and saponins. This test revealed the presence of different classes of chemical compounds in each of these extracts. (Table 2).

Table 1. Keck-list of medicinal plants species inventoried during the survey

N°	Botanical/ Scientific name	family	Local name (fourfold)	Parts used	Methods of preparation	Frequency	Others use/effects
1	*Khaya senegalensis*	Meliaceae	Delhi	Barks, roots	Maceration	6/59	Rheumatoid arthritis, Syphilis, leprosy [14,15]
2	*Pterocarpus erinaceus*	Fabaceae	Banohi	barks	Maceration	7/59	Febrifuge [16]
3	*Eucalyptus sp*	Myrtaceae		Leaves	Decoction	3/59	Antidiabetic, anticancer [17,18]
4	*Boswellia dalzielii*	Burseraceae	Andakedje	Barks, roots	Maceration	8/59	Venereal diseases, rheumatism [19]
5	*Flacourtia flavescens*	Flacourtiaceae		Barks	Decoction	5/59	Jaundice, stomach pain [20]
6	*Terminalia glaucescens*	Combretaceae	Koulahi	Barks, roots	Maceration	5/59	Hemorrhoids [21]
7	*Jatropha curcas*	Euphorbiaceae	Kolkoladjé/Magalehi	Leaves	Infusion	2/59	Hypertension, rheumatism, diabetes [22]
8	*Euphobia hirta*	Euphorbiaceae	Kosam-yel	Whole plant	Maceration	3/59	Skin diseases, bronchitis and asthma [23]
9	*Psorospermum febrifugum*	Hypericaceae	Cawayki	Leaves, barks	Maceration /Infusion	4/59	Epilepsy disease [24]
10	*Harungana madagascarensis*	Hypericaceae	Bourgal	Leaves	Infusion	4/59	Anti-haemorrhage, skin diseases[25, 26]
11	*Vitellaria paradoxa*	Sapotaceae	Karehi	Leaves, barks	Infusion	3/59	Cutaneous infection, stomach ailments [27]
12	*Aloes buettneri*	Liliaceae		Leaves	Maceration	4/59	Dysmenorrhea, general stomach aches [28]
13	*Citrus limonum*	RutaceaeMyrtaceae	Lemou	Leaves, Fruit	Infusion	1/59	Arthritis [29]
14	*Carica papaya*	Caricaceae	Dukudjee	Leaves, roots	Decoction	3/59	Colon cancer, heart attacks [18]
15	*Ocimum gratissimum*	Lamiaceae	kacuke	Leaves	Decoction	1/59	respiratory tract infections, skin diseases,and conjunctivitis [30]

Table 2. Phytochemical profile of methanolic crude extracts

Samples	Polyphenols	Tannins	Flavonoids	Sterols and tri terpenes	Glycosides	Alkaloids	Anthraquinones	Saponins
Bde	+	+	-	+	+	-	+	+
Bdr	+	+	+	+	+	+	+	-
Pe	+	+	+	+	+	+	+	-
Ff	+	+	+	+	-	-	+	-
Ks	-	-	+	+	-	+	-	-
Tge	+	+	-	+	-	+	-	+
Tgr	+	+	+	-	-	+	+	+

Key: + = Present; - = Absent; Tge: Terminalia glaucescens stem; Tgr: Terminalia glaucescens root; Ks: Khaya senegalensis; Pe : Pterocarpus erinaceus; Bde: Boswellia dalzielii stem; Bdr: Boswellia dalzielii root; Ff: Flacourtia flavescens

Table 3. Diameter of inhibition zones of methanolic crude extracts on bacteria at 25 mg/mL

Extrait souche	Tge	Tgr	Ks	Pe	Bde	Bdr	Ff	Cef
Ec	17.5 ± 0.5^{de}	17.5 ± 0.5^{bc}	19.5 ± 0.5^{e}	16.5 ± 0.5^{d}	18.5 ± 1.5^{d}	5.0 ±0.5^{ab}	19.5 ± 0.5^{e}	26.8 ± 0.3
Kp	18.5 ± 0.5^{e}	20.0 ± 0.0^{c}	22.0 ± 0.0^{f}	11.5 ± 0.5^{a}	16.5 ± 0.5^{cd}	10.5 ± 0.5^{bc}	10.5 ± 0.5^{b}	24.3 ± 0.8
PM	16.5 ± 0.5^{d}	18.0 ± 1.0^{c}	20.5 ± 0.5^{ef}	10.5 ± 0.5^{a}	13.5 ± 0.5^{ab}	11.5 ± 0.5^{c}	0 ± 0.0^{a}	27.5 ± 0.5
Pa	15.0 ± 0.0^{c}	15.5 ± 0.5^{ab}	15.5 ± 0.5^{b}	14.5 ± 0.5^{bc}	13.5± 0.5^{ab}	0.0 ± 0.0^{a}	10.5 ± 0.5^{b}	26.0 ± 0.5
St	14.5 ± 0.5^{c}	18.0 ± 2.0^{bc}	20.5 ± 0.5^{ef}	15.5 ± 0.5^{cd}	16.0 ± 1.0 ^{cd}	10.5 ± 0.5^{bc}	20.5 ± 0.5^{e}	28.0 ± 1.0
Stm	14.5 ± 0.5^{c}	18.5 ± 0.5^{bc}	12.0 ± 0.0^{a}	18.5 ± 0.5^{e}	17.5 ± 0.5^{d}	9.5 ± 0.5^{bc}	19.5 ± 0.5^{e}	22.5 ± 1.0
Spa	10.5 ± 0.5^{a}	14.5 ± 0.5^{a}	17.5 ± 0.5^{cd}	13.5 ± 0.5^{b}	13.0 ± 1.0^{ab}	0.0± 00^{a}	19.5 ± 0.5^{e}	29.3± 0.8
SPb	14.5 ± 0.5^{c}	17.5 ± 0.5^{bc}	19.0 ± 1.0^{de}	15.5 ± 0.5^{cd}	18.5 ± 1.5^{d}	10.0 ± 00^{bc}	20.5 ± 0.5^{e}	26.0 ± 0.0
Sa	12.5 ± 0.5^{b}	17.5 ± 0.5^{bc}	16.5 ± 0.5^{bc}	10.5 ± 0.5^{a}	11.5 ± 0.5^{a}	11.5 ± 0.5^{c}	13.5 ± 0.5^{c}	29.8 ± 0.3
BC	20.5 ± 0.5^{f}	27.0 ± 1.0^{d}	22.0 ± 0.0^{f}	19.0 ± 1.0^{e}	18.5 ± 1.5^{d}	13.5 ± 0.5^{c}	17.5 ± 0.5^{d}	29.5 ± 0.5

The values are the mean of the inhibition diameter ± standard error of the mean of 3 repetitions. a, b, c, d, and f: in the same column, the assigned values of the same letters are not significantly different (p <0.05); Ec: Escherichia coli; Kp: Klebsiella pneumoniae; PM: Proteus mirabilis; Pa: Pseudomonas aeruginosa; St: Salmonella tyhpi; Stm: Salmonella typhimurium; Spa: Salmonella paratyhi A; Spb: Salmonella paratyhi B; Sa: Staphylococcus aureus; BC, Bacillus cereus; Tge: Terminalia glaucescens stem; Tgr: Terminalia glaucescens root; Ks: Khaya senegalensis; Pe: Pterocarpus erinaceus; Bde: Boswellia dalzielii stem; Bdr: Boswellia dalzielii root; Ff: Flacourtia flavescens; ceftriaxone

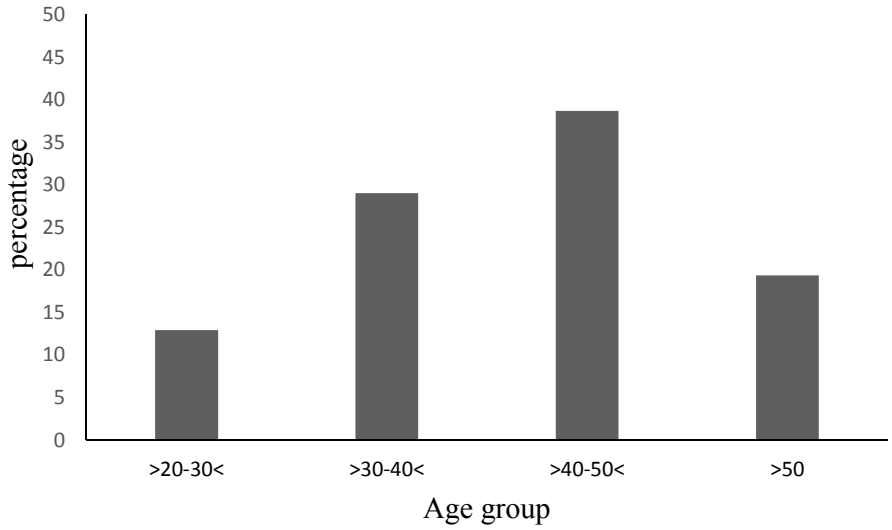

Fig. 1. Distribution of 31 traditional healers surveyed by age group

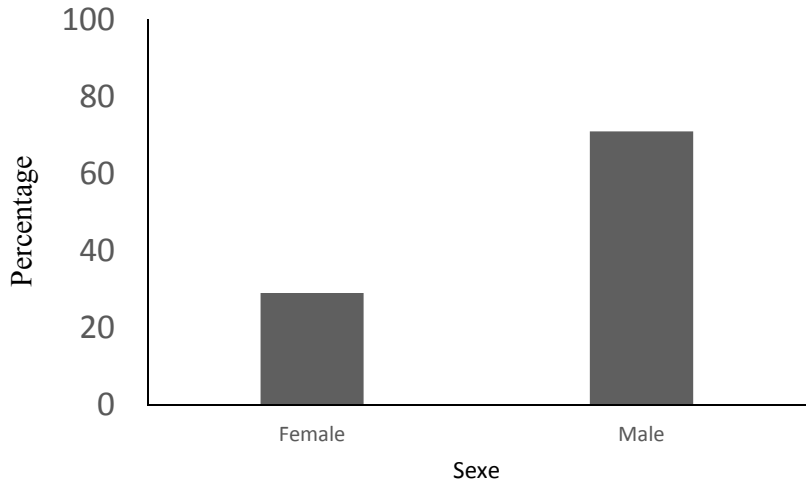

Fig. 2. Distribution of informant's sex

3.5 Sensitivity of Bacteria to Methanolic Crude Extracts

Table 3 summarizes the behaviour of different germs vis-à-vis the tested extracts. Except for *Flacourtia flavescens* extract, *Bacillus cereus* was the most sensitive bacterium. On the other hand, *Pseudomonas aeruginosa* is resistant to 4 extracts (Tgr, Ks, Bde and Bdr) followed by *Salmonella* para typhi A which is resistant to The, Tgr, Bde and Bdr.

3.6 MIC and CMB of the Crude Methanolic Extracts

It can be seen from Table 4 that *Terminalia glaucescens* bark extracts as well as root extract of *Pterocarpus erinaceus, and Flacourtia flavecens* showed a good activity about Gram-positive bacteria with MICs varying between 0.75 mg/mL and 1.5 mg/mL. In contrast, *Boswellia dalzielii* bark extract had the smallest activity with a MIC of 12 mg/mL and CMB> 12 mg/mL

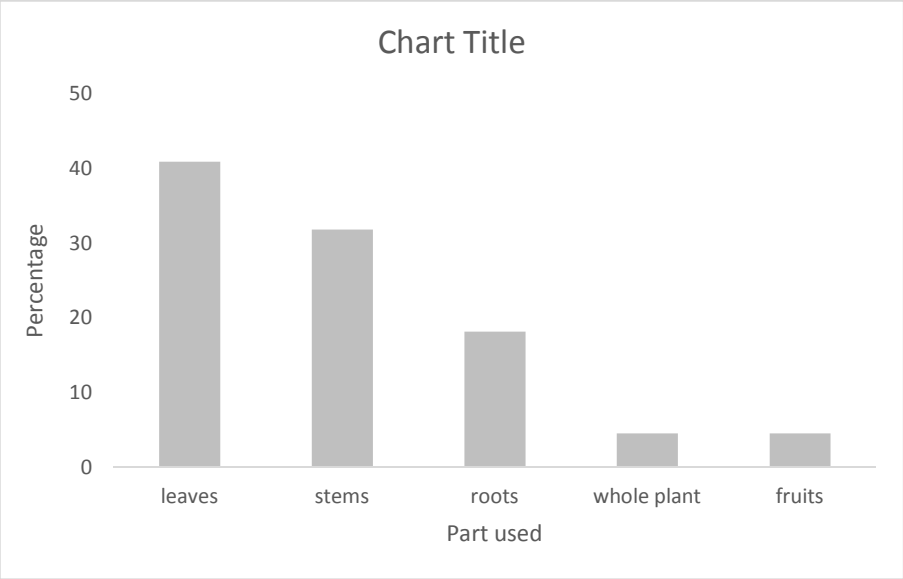

Fig. 3. Repartition of plants according to the parts used

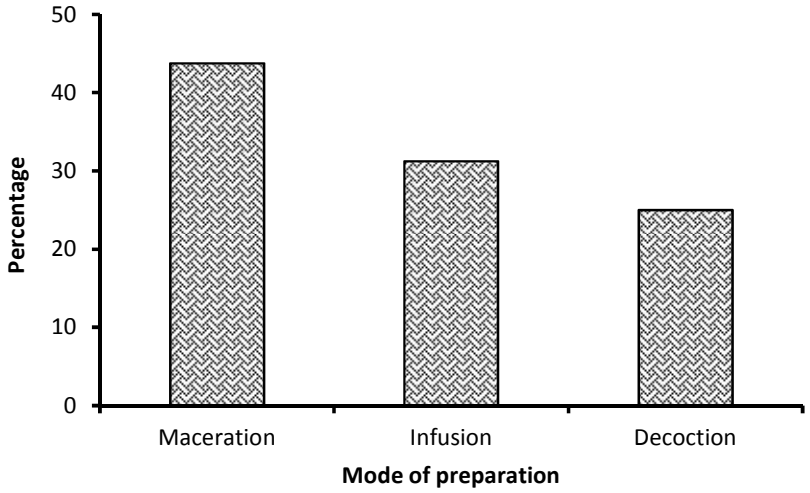

Fig. 4. Repartition of plants according to the mode of preparation

4. DISCUSSION

According to the survey in the Vina and mayo-Louti divisions, a total 15 medicinal plants belonging to 12 botanical families were used in treating different infectious diseases.

From Table 1, *Pterocarpus erinaceus* and *Boswellia dalzielii* were the most common plants reported to be used in the management of infectious diseases in the northern region with frequencies of 8 (13.6%) and 7 (11.86%) respectively. *Boswellia dalzeilii* is a species of the Genus Boswellia that grows in the northern part of Cameroon[31].

Three plants species (*Boswellia dalzielii*, *Flacourtia flavescens* and *Terminalia glaucescens*) presented higher frequencies of citation. This may be linked to their efficacy since these plants are reported, in Cameroon as well as in other parts of the world, to be used for the treatment of infectious diseases [31-33].

Table 4. Minimal Inhibitory Concentrations (MIC) in mg/ml of Methanolic crude extract against bacterial strains

Extract		Ec	Kp	PM	Pa	St	Stm	*Sa*	*Bc*	*SpA*	*SpB*
Tge	CMI	3.0	3.0	3.0	3.0	1.5	1.5	1.5	1.5	3.0	1.5
(mg/mL)	CMB	>12	12	12	>12	>12	>12	12	12	>12	>12
	CMB/CMI	>4	4	4	>4	>4	>4	>4	>4	>4	>4
Tgr	CMI	1.5	3.0	1.5	3.0	3.0	3.0	1.5	1.5	3.0	3.0
(mg/mL)	CMB	>12	>12	12	>12	>12	>12	>12	6	12	>12
	CMB/CMI	>4	>4	>4	>4	>4	>4	>4	4	>4	>4
Pe	CMI	0.8	6.0	3.0	3.0	0.8	0.8	0.8	0.8	1.5	1.5
(mg/mL)	CMB	6	12	12	12	6	3.0	6	6	12	>12
	CMB/CMI	>4	2	4	4	>4	4	>4	>4	>4	>4
Bde	CMI	3.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	6.0	3.0
(mg/mL)	CMB	>12	>12	>12	>12	>12	>12	>12	>12	>12	12
	CMB/CMI	>4	>4	>4	>4	>4	>4	>4	>4	>4	4
Bdr	CMI	3.0	3.0	0.8	3.0	3.0	3.0	1.5	3.0	1.5	3.0
(mg/mL)	CMB	6	>12	6	6	>12	>12	>12	6	12	>12
	CMB/CMI	2	>4	>4	2	>4	>4	>4	2	>4	>4
Ks	CMI	1.5	3.0	1.5	6.0	1.5	3.0	3.0	1.5	6.0	1.5
(mg/mL)	CMB	6	6	6	>12	>12	12	>12	>12	6	12
	CMB/CMI	4	2	4	>4	>4	4	>4	>4	1	>4
Ff	CMI	3.0	0.8	6.0	6.0	3.0	3.0	0.8	0.8	1.5	0.8
(mg/mL)	CMB	>12	6	12	>12	>12	>12	6	3.0	6	12
	CMB/CMI	>4	>4	2	>4	>4	>4	>4	4	>4	>4
Cef	CMI	6.25	6.3	12.5	12.5	3.1	6.25	3.1	6.3	12.5	6.3
(µg/mL)	CMB	25	25	50	50	25	25	25	50	50	25
	CMB/CMI	4	4	4	4	>4	4	>4	>4	4	4

Ec : Escherichia coli ; Kp : Klebsiella pneumoniae ; Pm : Proteus mirabilis ; Pa : Pseudomonas aeruginosa ; St : Salmonella tyhpi ; Stm : Salmonella typhimurium ; Spa : Salmonella paratyhi A ; Spb : Salmonella paratyhi B ; Sa : Staphylococcus aureus ; BC, Bacillus cereus Tge: Terminalia glaucescens stem; Tgr: Terminalia glaucescens root; Ks: Khaya senegalensis; Pe: Pterocarpus erinaceus; Bde: Boswellia dalzielii stem; Bdr: Boswellia dalzielii root; Ff: Flacourtia flavescens; cef : ceftriaxone

Indeed, ethnobotanical surveys in many Cameroonian localities reported that *Boswellia dalzielii*, *Flacourtia flavescens* and *Terminalia glaucescens* are used for the treatment of malaria, shingles, ringworm [34,35]. These traditional knowledge on the therapeutic effects of the above medicinal plants are confirmed by various pharmacological study data, which demonstrated immunomodulatory activities of *B. dalzielii* aqueous extract and methanol fraction [31], the antibacterial activities of *T. glaucescens* of ethanol extract of bark and root with MIC between 0.625 to 1.25 mg/ml [21], the antioxidant properties of methanolic extracts of *Flacourtia flavescens* [36].

From Fig. 1 it is noted that thirty-one (31) traditional healers were interviewed. The informants were between 20 and over 50 years old, and the modal class was 40 to 50 years old. Among these informants, there were nine women and 22 men (Fig. 2). These small number could be because traditional healers are scarce throughout our country [37] and thus represent a very little portion of the general population and also because some of them refused to be interviewed. This might also be because, young people to whom traditional knowledge on medicinal plants effects could have been transmitted are not eager to learn and exile to city for jobs and better living condition purposes [37]. This situation is the same worldwide since cultural changes as a result of westernization and modernization have contributed enormously in making the younger generation undermine African traditional values [38]. The low representativeness of women in this study is due, on the one hand, to the fact that traditional medicine has long been exercised by men and also to the fact that in these Regions women are not allowed to interact with foreigners.

Data from Fig. 3 showed that, the most commonly used plant parts were the leaves (40.91%). In fact, leaves are known to accumulate plants secondary metabolites such

as alkaloids, tannins and saponin, which are active components responsible for many medicinal properties [39]. Moreover, utilization of leaves and stems is advantageous since their harvest does not induce irreversible destruction of plants like that of roots or whole plant [40].

Medicinal plants were prepared in different forms including maceration (43.75%), infusion (25.25 %) and decoction (25.00%) (Fig. 4). These preparations are made only with water and orally administered. These modes of preparation and administration are the most used in traditional medicine. Similar results were obtained in previous ethnobotanical surveys carried out in Cameroon and another part of the world [38,41, 42]. The high frequency of maceration is related to the fact that this method does not alter the active principle of infusion and decoction do.

4.1 Antimicrobial Activity of Selected Plants

According to Popova et al., [43] scale, which state that natural products with minimum inhibitory concentrations (MIC) range between 100–1000 µg mL^{-1} *in vitro* on at least one Gram-positive and one Gram-negative bacteria can be classified as antimicrobials, crude extract of *Pterocarpus erinaceus* and *Flacourtia flavescens* shown good antibacterial activity (MIC = 750 µg/ml).

These observations corroborate those authors, who confirmed the use of these plants in the treatment of infectious diseases [34,44,45]. This may be ascribed to the different classes of compounds found in these extracts. In fact, the phytochemical screening of these extracts revealed the presence of phenols, tannins, terpenoids, flavonoids, steroids, alkaloids, anthraquinones, anthocyanins, saponins and coumarins. Individual antibacterial activities of these secondary metabolites have been demonstrated [46,47]. Nevertheless, *Boswellia dalzielii* root extract was active only against *P. mirabilis*. But, *Terminalia glaucescens* stem extract, *Terminalia glaucescens* root extract and *Khaya senegalensis* extract shown moderate activity (MIC 1500 to 3000 µg/mL) depending on the bacterium.

The antibacterial activity of *Boswellia dalzeilii* from Cameroon are reported here for the first time. The values of the diameters of inhibition, MICs and MBC showed that the degree of activity varied with the bacteria and the extracts. This variation of the activity could be due to the difference of solubility of the active ingredient in each extract on the one hand and to the constitutional or structural variability of the tested germs on the other hand. Also, it could be due to the capacity of the organisms to modify the structure of the active principle [2]. Moreover, the differences in susceptibility may be explained by the differences in cell wall composition and genetic content of plasmids that can be easily transferred among strains.

5. CONCLUSION

This ethnobotanical survey study has revealed that there are high knowledge and use of medicinal plants in northern Cameroon. Methanol crude extract of different plants showed different degrees of antibacterial activities against bacterial strains enteropathogenic used. These biological results allowed us to conclude that the methanol extracts of the *Boswellia dalzielii* roots as well *Flacourtia flavescens* and *Pterocarpus erinaceus* barks are the most active. The information from this study can serve as guide for the discovery of new antibacterial drugs from medicinal plant

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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