Screening of Some Plants Used in the Cameroonian Folk Medicine for the Treatment of Infectious Diseases

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Abstract

The present study was designated to evaluated the antimicrobial activities of methanol, ethanol, hexane, ethyl acetate, aqueous, mixture methanol/water and ethanol/water extracts of *Pentadiplandra brazzeana*, *Erythrina sigmoïdea, Petersianthus macrocarpus*, *Clerodendrum umbellatum* , *Sida acuta* , *Eleusine indica* , *Bridelia micrantha* and *Musanga cecropioides* which are plants used as traditional folk medicine in Cameroon for the treatment of different infections and disorders as gastrointestinal disorders. The antimicrobial activities of the extracts against 17 laboratory strains belong to 15 bacterial species and 2 yeasts implicated in gastrointestinal disorders were evaluated based on the inhibition zone using the disc diffusion assay, minimal inhibition concentration and minimal bactericidal concentration values. 89.6% of the extracts tested have an inhibitory effect at 1.25 mg against at least one of the microorganism tested with the diameter of inhibition zone values ranging from 8 to 27 mm. 62.5% of the broader spectrum of antimicrobial activity of plant material was obtained with methanol extract. The most susceptible bacterium was *Shigella flexneri and Enterobacter cloacae* the most resistant. Ethanol/Water extract of *Pentadiplandra brazzeana* presented a good activity against *Proteus vulgaris* with MIC and MBC of 78 and 250 µg/ml respectively. The weak activity was obtained with Methanol extract *of Musanga cecropioides* against *Klebsiella pneumonia*. The results might explain the ethnobotanical use of the studied species for the treatment of gastrointestinal infections.

Keywords: Medicinal plants, Antimicrobial activity, Gastrointestinal disorders

1. Introduction

Opportunistic infections are becoming common because of the growing number of immunocompromised individuals (Neeta *et al*., 2011). In developing countries, therapy with synthetic antibiotics is not always possible due to their high cost. To overcome this problem, people use preparation obtained from plants growing in their countries following folk tradition but without any scientific support (Fabiola *et al.*, 2002). In recent year, multidrug resistance in human pathogenic microorganism has developed due to indiscriminate use of commercial antimicrobial drug commonly use in the treatment of infectious diseases (Bennish *et al*., 1984; Minshi *et al*., 1987). Resistance to quinolone antibiotic has been reported for *shigella dysenteriae* type 1 which rapidly develops resistance to the current therapy (Dutta *et al* , 2003; Sivapalasingan *et al*, 2006).This situation forced

the scientists for searching new antimicrobial substances from various sources, like medicinal plants, which are good source of novel antimicrobial chemotherapeutic agents (Hardman *et al*., 1992).

This paper report the *in vitro* antibacterial and anti-candidal screening of 48 extracts of eight medicinal plants against 17 human pathogenic bacteria and yeast implicated in gastrointestinal infection. The plants species selected are use as traditional medicine in Cameroon for the treatment of illnesses which included epilepsies, headache, irregular menstruation, infective dermatitis, asthma, diarrhea, male sexual impotence, thyphoenteritis, dysentery, tubal blockage, intestinal helminthiasis. The ethnobotanical data on the use of these plants and the selection of the plant part to be tested where complemented with a biographic review (Adjanohoun *et al*., 1996).

2. Material and Methods

2.1 Plant collection

Plant material of *Pentadiplandra brazzeana*, *Erythrina sigmoïdea* , *Petersianthus macrocarpus*, *Clerodendrum umbellatum* , *Sida acuta* , *Eleusine indica* , *Bridelia micrantha* and *Musanga cecropioides* were collected in October 2010, in their natural habitat in 2 regions of Cameroon; Mount Eloumdem in the centre province and Foumbam in west province. Voucher specimens were identified at the national herbarium Yaoundé-Cameroon (Table 1).

2.2 Preparation of extracts

Plant materials were then air dry at room temperature. The dry plant materials were ground in a fine powder. Extraction of plant material was carried out by soaking the dried powdered of each plant (250 g) in bottle with 3.5 l of methanol (M), ethanol (E), ethyl acetate(EA), Water(W), methanol/water (M/W 1/1), ethanol/water (E/W 1/1), or hexane(H) and kept for 72 hours. The plant-solvent mixture was then sieved. The filtrate (extract) was concentrated by evaporating under vacuum using a rotary evaporator. The extract was further concentrated by allowing it to stand overnight in an oven at 30°C. The yield of the extraction was calculated by divided the weight of the extract obtained by the weight of the dried material plant extracted.

2.3 Microorganisms

The clinical microorganisms included here for the antimicrobial activity screening were the most common strains implicated in gastro-intestinal disorder such as diarrhea and dysentery. The choice of the microorganism was oriented by the fact that all the plants are used traditionally to treat gastrointestinal disorder. They were 15 bacterial and 2 yeast stains : *Escherichia coli (E. coli), Klebsiella pneumoniae (K. pneumoniae), Shigella dysenteriae type 1 (S. dysenteriae), Shigella flexneri (S. flexneri), Morganella morganii (M. morganii), Proteus vulgaris (P. vulgaris), Proteus mirabilis (P. mirabilis), Salmonella typhi (S. typhi), Citrobacter freundii (C. freundii), Enterobacter cloacae (E. cloacae), Enterobacter agglomerans (E. agglomerans), Staphylococcus aureus (S. aureus), Streptococcus feacalis (S. feacalis), Pseudomonas aeruginosa (P. aeruginosa), Bacillus cereus T (B. cereus T), Candida albicans (C. albicans) and Candida glabrata (C. glabrata)*. These microorganisms were obtained from Bacteriology and Mycology Laboratories of Centre Pasteur of Yaoundé-Cameroon and *Bacillus cereus T* was obtained from the A.F.R.C. Reading Laboratory of Great Britain.

2.4 Antibacterial and antifungal assay

2.4.1 Disc diffusion assay

The dried plant-extract was dissolved in the same solvent of extraction to a final concentration of 125 mg/ml. Sterile paper disc (6 mm of diameter) prepared from Whatman number one filter paper were impregnated with 10 µl of the crude extract of the plant as described by Edward et al (1980) from a stock of 125 mg/ml. Each disc contains 1.25 mg of the extract. These paper discs were kept in an incubator at 37°C for 24 hours to evaporate the solvent. Antimicrobial tests were then carried out by disc diffusion method (Murray *et al*., 1996).

100 µl of the suspension of the tested microorganism (0.5 Mc Farland standard turbidity) containing 10^8 CFU/ml of bacterial, 10^6 CFU/ml of yeast prepared from an overnight Mueller Hinton agar culture for bacterial and Sabouraud dextrose agar for yeast was used to seed each prepared and dried Mueller Hinton agar plate for bacteria and Sabouraud dextrose agar for yeast. The discs were arranged and firmly pressed on the agar surface of each seeded plate. These plates, after staying at 4°C for 2 hours were incubated aerobically at 37°C for 24 hours for bacteria and at 25°C for 24 hours for yeast.

Similarly, antimicrobial susceptibility testing was performed also against some tested micro-organisms by the same method with commercially available disks of Ampicilin 10 µg, Colistin 10 µg, Erythromycin 15 µg, Chloranphenicol 30 µg, Sulfamicin 25 µg, Spectinomycin 25 µg, Tobramycin 2 µg, Clindamycin 10 µg, Dibekacin 10 µg and Cefoxitin 30 µg. Negative control was also prepared using the same solvent employed to dissolve the

plant extract. Antimicrobial activity was evaluated by measured the zone of inhibition against the tested microorganism. The result recorded for each bioassay was the average of 3 tests.

2.4.2 Determination of MIC and MBC

The MIC and MBC values were also evaluated for the microorganisms that were determined as more susceptible to the best solvent extract of each plant material tested in disc diffusion assay using the broth microdilution method (NCCLS. 1999). The test was performed in peptone water supplemented with glucose 1% (w/v) with red phenol as a colour indicator (PPG1%). Bacterial strains were cultured overnight at 37°C in Muller Hinton and yeast strains at 25°C in Sabouraud dextrose agar. Test strains were suspended in normal saline (NaCl 9‰), adjusted to 0.5 Mc Farland standard turbidity and suspended in PPG1% to give a final density of $5x10^5$ CFU/ml.

For the susceptibility test, the 96-well round bottom sterile plates were prepared by dispensing 180 µl of each inoculated broth into wells. Each line of well was used for one test microorganism. A 20 µl aliquot of the plant extract was added. The concentration of extract adopted to evaluate the antimicrobial activity was included from 12.8 to 0.00038 mg/ml. one well was considered as growth control since no extract solution was added. The final volume of each well was 200 µl. The content of each well was mixed and then incubated under normal atmospheric condition at 37°C for 24 hours (for bacterial strains) and at 25°C for 24 hours (for yeast strains).

The bacterial and yeast growth was indicated by the colour change of the well content from the red to yellow. The MIC was defined as the lowest concentration of the extract to inhibit the growth of microorganism (1^{st} red well content of each line) and confirmed by platting 5 µl sample from that red well on Mueller Hinton agar for bacteria strains or on Sabouraud dextrose agar for yeast strains. MBC were determined by platting 5 µl sample from red wells on Mueller Hinton agar or on Sabouraud dextrose agar without extract. The MBC was the concentration at which there was not microbial growth. The extract testing in this study was screening three times against each microorganism.

2.5 Phytochemical screening

The freshly prepared extract of active plant was chemically tested qualitatively for the presence of chemical constituents such as alkaloids, anthocyanins, flavonoids, saponins, tannins, anthraquinones, polyphenols, sterols and/or triterpenes, anthocyanins, glycosides, anthranoids and steroids. They were identified using characteristic colour changes using standard procedures previously described (Odebiyi and Sofowora, 1978). Each test was qualitatively expressed as negative (-) or positive (+); the intensity of the characteristic colour was expressed as (++) or (+++).

3. Result and Discussion

3.1 Antibacterial and antifungal assay

3.1.1 Disc diffusion assay

The antimicrobial activity of each extract against microorganisms examined in the present study and their potency were qualitatively and quantitatively assessed by the presence or absence of inhibition zone and zone diameter, MIC and MBC values. The results were given in Table 2, 3 and 4. The results showed that 89.6% of the extracts evaluated have an inhibitory effect against at least one of the microorganism tested with the diameter of inhibition zone values ranging from 8 to 27 mm (Table 2). 6 of the extract evaluated have an antimicrobial activity against average of the strains tested with the activity spectrum of 52 to 58 % for the most active one (figure 1). Ethanol / Water extract *of P. brazzeana* with an activity spectrum less than the average showed the maximal diameter of inhibition zone values of 23 and 27 mm respectively against *P. vulgaris* and *S. dysenteriae*. These antimicrobial activities were compared with those obtained with the commercial disc (Table 3). Our data showed that all the pathogenic strains were susceptible to erythromycin and the stronger zone diameter was obtained with the same antibiotic (37 mm).

The activity spectrum of any plant materials depends of the solvent of extraction used. 62.5% of the broader spectrum of antimicrobial activity of plant material was obtained with methanol extract. Based on these results, it is possible to conclude that methanol extract has stronger and broader spectrum of antimicrobial activity as compared to hexane, water or ethanol extract (figure 1). This observation confirmed the evidence of the previous study reported that methanol is the better solvent for extraction of antimicrobial substances from medicinal plants than water, ethanol, ethyl acetate or hexane (Ahmad et al., 1998; Eloff et al., 1998; Lin et al., 1999).

The most susceptible bacterium was *Shigella flexneri* following by *Shigella dysenteriae, Proteus vulgaris, Staphylococcus aureus* and *Streptococcus faecalis* (figure 2). *Enterobacter cloaca* was the most resistant bacterium tested since not extract evaluated here had showed any inhibitory activity against it. This kind of

differences in susceptibility within or between the bacterial strains of the same species against antimicrobial substances in plants extract may be explained by the differences in cell wall composition and/or inheritance genes on plasmids that can be easily be transferred among bacterial strains (Karaman *et al*., 2003). Only few extracts showed anti-candidal activity with maximal inhibition zone diameter of 12 mm.

3.1.2 Determination of MIC and MBC

The MIC and MBC value obtained using the broth microdilution method is given in Table 4. It was considered that if the extracts displayed an MIC less than 100 µg/ml, the antimicrobial activity was good ; from 100 to 500 µg/ml the antimicrobial activity was moderate; from 500 to 1000 µg/ml the antimicrobial activity was weak; over 1000 µg/ml, the extract was considered inactive (Fabiola *et al*., 2002). It was also considered that if the extracts displayed an MIC of 8 mg/ml or below against any of the yeast tested, the antimicrobial activity was good (Navarro *et al*., 2003). Our results shown that most of the extract presented a moderate activity against the pathogenic bacteria tested. Ethanol/Water extract of *P. brazzeana* presented a good activity against *P. vulgaris* with MIC and MBC of 78 and 250 µg/ml respectively. The weak activity was obtained with methanol extract *of M. cecropioides* against *K. pneumonia*.

3.2 Phytochemical screening

From Table 5, it is seen that flavonoids, polyphenols, glycosides, Alkaloids, triterpenes and / or sterols are the major compounds in some active extract. The presence of these chemical compounds in extracts may explain some of their antimicrobial actions since antimicrobial actions of most of these phytochemical substances have been documented (Plasuntherum, 1982; Palacious, 1983; Ahmad, 1986). However, the antimicrobial activities demonstrated by the extract could be due to the presence of other antimicrobial substances not covered by the screening.

4. Conclusion

The results in the present work indicate that the plant species assayed possess antimicrobial properties. The presence of flavonoids, saponins, tannins, polyphenols, sterol and/or triterpenes in extracts may explain their antimicrobial activities.This explains the use of these plants in folk medicine for the treatment of various diseases whose symptoms might involve bacterial infections and underline the importance of the ethnobotanical approach for selection of plants in the discovery of new bioactive compounds. At present, our group is concerned with the fractionation and the isolation of pure compounds and the elucidation of their structures in order to better evaluate their pharmacological activity in vitro and in vivo.

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Table 1. List of the medicinal plants used in the antimicrobial and antifungal assay

Species (family) Voucher specimen number	Local name	Plants parts tested	Popular uses
Pentadiplandra brazzeana (Pentadiplandraceae) 3612/SRK.	Gouga-kpou (Banka) Ndemboumbomou (Ewondo)	Leaves	diarrhea
Erythrina sigmoïdea (Leguminosae-Fabaceae) 26645SRF.Cam	Megham (Bamoun)	Stem bark	venereal diseases, stomach ulcers, dysentery, leprosy
Petersianthus macrocarpus (Lécythidaceae) 1710SRFK	Abing (Ewondo)	Stem bark	dysentery
Clerodendrum umbellatum (Verbenaceae) 17492SRF/Cam	Nganwe (Bafut) Elok-dibi (Ewondo)	Leaves	Epilepsy, headaches, anti-helmint, irregular menstruation, skin infections, asthma gastro-intestinal. disorders
Sida acuta (Malvaceae) 17364SRF/Cam	Zeyssim (Bulu)	Whole plant	Sexual impotent, diarrhea , abdominal pains, female infertility.
Eleusine indica (Poaceae) 14343/SRF.Cam	Ngongui (Bassa) Sargalde (Ewondo)	Whole plant	diarrhea, dysentery, épilepsy, intestinal occlusion
Bridelia micrantha (Euphorbiaceae) 14291/SRF/Cam	Ewolet (Ewondo) Kakzeu (Bandjoun)	Stem bark	diarrhea, dysentery, diabetes, sterility
Musanga cecropioides (Moraceae) 20889/SRF Cam	Echem afok (Ejagham) Asseng (Ewondo)	Stem bark	typhoïd

Table 2. Antimicrobial activity of eight plants against 17 pathogenic microorganisms using *Disc diffusion assay*

Stains tested	plants extract																							
	P. brazzeana						*E. sigmoïdea*						*M. cecropioides*						*P. macrocarpus*					
	M	M/W	E	E/W	A	W	M	M/W	E	E/W	A	W	M	M/W	E	E/W	A	W	M	M/W	E	E/W	A	W
E. c.	7	7	13	8	13	-	-	11	9	9	-	-	11	10	12	14	-	-	-	-	-	-	10	-
S. t.	11	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	7	-	12	-
S. d.	17	17	12	23	10	-	-	9	14	11	7	-	-	-	-	7.5	-	-	11	10	10	9	11	-
S. f.	14	-	10	11	9	11	-	-	-	-	-	-	9	-	9	9.5	11	-	14	11	13	11	13	-
M. m.	8	8	11	7	9	-	-	-	-	-	-	-	9	-	-	8.5	-	-	9.5	-	-	-	13	-
P. v.	18	19	18	27	12	-	-	13	14	11	9	10	-	-	-	14	-	9.5	-	-	-	-	11	-
K. p.	-	-	-	-	-	-	-	-	-	-	-	-	14	-	-	10	-	-	-	-	-	-	-	-
P. m.	-	15	13	20	-	-	-	-	-	13	10	-	-	-	-	-	-	-	-	-	-	-	-	-
C. f.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
En. c.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
En. a.	-	12	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
St. a.	-	15	11	10	-	-	10	-	-	-	12	-	10	-	12	-	-	-	12	-	10	-	-	-
B. c.	8	10	11	8	-	-	-	-	-	-	10	-	-	-	-	-	-	-	9	-	-	-	10	-
St. f.	13	-	-	17	10	-	-	-	-	-	10	-	12	-	-	-	13	-	12	-	-	-	17	-
P. d.	-	-	-	-	-	-	-	-	-	-	10	-	11	-	-	-	-	-	-	-	-	-	-	-
C. g.	8	-	-	-	-	-	-	-	8	-	10	-	-	-	-	10	-	-	11	-	9	-	-	-
C. a.	-	-	-	12	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9	-	-	-	-	-

Stains tested	plants extract																							
	C. umbellatum						*S. acuta*						*E. indica*						*B. micrantha*					
	M	M/W	E	E/W	A	W	M	M/W	E	E/W	A	W	M	M/W	E	E/W	A	W	M	M/W	E	E/W	A	W
E. c.	11	-	11	8	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. t.	14	7	9	7	-	9	15	17	-	-	-	-	10	-	-	-	-	-	-	11	18	12	-	-
S. d.	7.5	-	8.5	-	-	10	10	10	10	-	-	-	-	-	-	-	-	-	-	14	18	17	-	-
S. f.	10	-	-	10	-	7	10	12	-	-	-	-	-	-	-	-	-	-	-	-	9	9.5	9.5	-
M. m.	9	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	17	-	9	-
P. v.	10	-	-	-	-	-	14	9	-	-	-	-	-	-	-	9	-	-	-	-	10	-	-	-
K. p.	13	-	11	9	-	-	11	10	-	-	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-
P. m.	9	-	-	-	-	-	-	-	10	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. f.	-	8.5	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-	-	-
En. c.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
En. a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	12	-	-	-
St. a.	-	-	10	-	13	-	17	-	13	-	-	-	10	10	12	-	15	-	-	-	11	-	-	-
B. c.	-	-	10	-	-	-	9	11	10	-	-	-	-	-	10	-	9	-	-	-	-	-	-	-
St. f.	9	-	11	-	-	-	8.5	-	-	-	12	-	11	-	-	-	-	-	-	-	12	-	13	-
P. d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-
C. g.	10	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
C. a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Values are the mean of three independent determinations; the variation was less than 1/100

(-): Diameter = 6 mm; M: Methanol; M/W: Methanol/Water (1/1); E: Ethanol; E/W: Ethanol/Water(1/1); A: Ethyl acetate; W:Water; E.c: *Escherichia coli*; S.t.: *Salmonella typhi*; S.d.: *Shigella dysenteriae*; S.f.:*Shigella flexneri*; M.m.: *Morganella morganii*; P.v.: *Proteus vulgaris*; K.p.:*Kebsiella pneumonia*; P.m.: *Proteus mirabilis*; C.f.: *Citrobacter freundii*; B.c.: *Bacillus cereus*; En.c.: *Enterobacter cloacae*; En.a.: *Enterobacter agglomerans*; St.a.; *Staphylococcus aureus*; St.f.: *Streptococcus faecalis*, P.d.; *Pseudomonas aeruginosa*; C.g.: *Candida albicans*; C.a.: *Candida glabrata*

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Table 3. Antimicrobial susceptibility test performed with commercially available disks using Disc diffusion assay

Antibiotics	*Pathogenic strains*													
	E. c.	***S. t.***	***S. d.***	***S. f.***	***P. v.***	***K. p.***	***En. c.***	***St. a.***	***St. f.***	***M.m***	***C.f***	***P.a***	***C.a***	***C.g***
Colistin	10	7.5	14	7	8	8.5	6	9	7	14	11	10	NT	NT
Spectinomycin	12.5	9.5	12	13.5	23.5	8	12	12.5	13.5	12.5	13.5	12	NT	NT
Erythromycin	37	32.5	12	31.5	21.5	12	14.5	32.5	10.5	8	12.5	13.5	NT	NT
Sulfamicin	10.5	7	6	9.5	6	9	6	10	6	7	6	7	NT	NT
Tobramycin	13.5	14	6	12.5	10	7	6	12.5	14.5	9	11.5	8	NT	NT
Clindamycin	25.5	25	6	8	8	10.5	6	10.5	16	10.5	10	10	NT	NT
cefoxitin	6	6	6	6	6	10	6	10	10	6	8	10	NT	NT
Chloranphenicol	23.5	20.5	24	6	18.5	9.5	18.5	28	22.5	12.5	7	8	NT	NT
Dibekacin	27.5	18	18	8.5	6	10	16	16	12	10	8	11	NT	NT
Ampicilin	6	6	6	6	10	10	6	6	12.5	6	14	7	NT	NT
Nystatin	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	21.5	17.5

Values are the mean of three independent determinations; the variation was less than 1/100. NT: not tested

E.c: *Escherichia coli*; *S.t.*: *Salmonella typhi*;,*S.d.: Shigella dysenteriae*; *S.f.*: *Shigella flexneri*; *P.v.*: *Proteus vulgaris*; *K.p.:Kebsiella pneumonia*; *En.c.*: *Enterobacter cloacae*; *St.a.*: *Staphylococcus aureus*: *St.f*: *Streptococcus faecalis*; *M.m*: *Morganella morganii*; *C.f*: *Citrobacter freundii*; *P.a*: *Pseudomonas aeruginosa*; *C.a*: *Candida albicans*; *C.g*: *Candida glabrata*

Table 4. The MIC and MBC values of the plant material extracts against the microorganisms tested using microdilution assay

Plants material (Solvent of extraction)	***P. brazzeana* EtOH/ Water**	***E. sigmoïdea* EtOH**	***M. cecropioides* EtOH/Water**	***M. cecropioides* MeOH**	***P. macrocarpus* Ethyl Ac**	***P. macrocarpus* MeOH**	***C. umbellatum* Ethyl Ac**	***S. acuta* MeOH/ Water**	***S. acuta* MeOH**	***E. indica* Ethyl Ac**	***B. micranthia* EtOH**
Strains tested	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**	CMI **CMB**
P.v	78 **250**	100 **800**	312 **1600**	NT	NT	NT	NT	NT	NT	NT	NT
S.d	100 **800**	800 **6400**	NT	NT	NT	NT	NT	NT	NT	NT	100 **3200**
E.c	NT	NT	312 **2500**	NT	NT	NT	NT	NT	NT	NT	NT
K.p	NT	NT	NT	1250 **6400**	NT	NT	NT	NT	NT	NT	NT
St.f	NT	NT	NT	NT	100 **800**	NT	NT	NT	NT	NT	NT
St.a	NT	NT	NT	NT	NT	NT	50 **1600**	NT	312 **1250**	78 **400**	NT
S.t.	NT	NT	NT	NT	NT	NT	NT	100 **400**	NT	NT	50 **400**
C.a	800 **1600**	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Values are the mean of three independent determination; the variation was less than 1/100 000. *E.c: Escherichia coli; St.a: Staphylococcus aureus*; *P.V: Proteus vulgaris*; *S.d: Shigella dysenteriae*; *St.fe: Streptococcus faecalis; S.t: Salmonella typhi*; *K.p.: Kebsiella pneumoniae. C.a*: *Candida albicans*; *C.g.*: *Candida glabrata*;.MIC: minimal inhibition concentration (µg/ml). MBC: minimal bactericidal concentration (µg/ml). NT: not tested

Table 5. Chemical composition of plant extracts

Plants extract **Chemical compounds**	***P. brazzeana* EtOH/ Water**	***E. sigmoïdea* EtOH**	***M. cecropioides* MeOH**	***P. macrocarpus* Ethyl Ac**	***C. umbellatum* Ethyl Ac**	***S. acuta* MeOH**	***E. indica* Ethyl Ac**	***B. micrantha* EtOH**
Alkaloids	-	++	-	++	-	++	–	+
Saponins	-	-	+	-	-	-	+	+
Tannins	-	-	+	-	+	-	-	+
Antraquinones	-	-	-	-	-	++	-	++
Polyphenols	-	+	–	+	+	–	+	+
Sterols and/or Triterpenes	+	+	++	++	-	-	++	+
Glycosides	++	-	+++	-	++	-	-	+
Anthranoid	-	-	-	-	-	-	-	-
Steroids	-	+	-	-	+	-	+	-
Flavonoids	+	++	+	++	++	+	++	++
Anthocyanin	++	-	-	-	+	+	-	-

(–): Absence of chemical compound; (+): Presence of chemical compound; (+) < (++) < (+++): Base of the intensity of characteristic colour

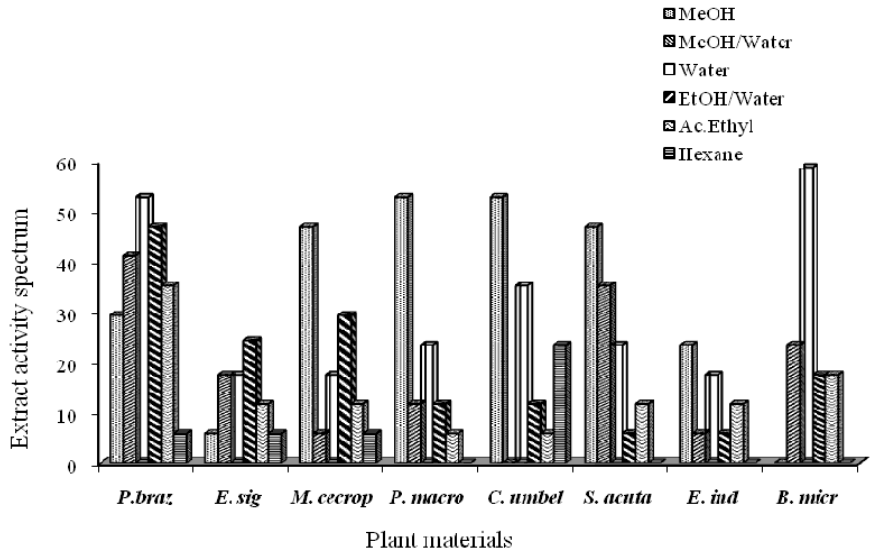

Figure 1. Effect of extraction solvents on the antimicrobial activity of plants. P.bra: *Pentadiplandra brazzeana*, E. sig: *Erythrina sigmoïdea*, P. macro: *Petersianthus macrocarpus*, C. umbel: *Clerodendrum Umbellatum*, S. acuta: *Sida acuta*, I.ind: *Eleusine indica* , B. micr: *Bridelia micrantha* and M.cecrop: *Musanga cecropioides*

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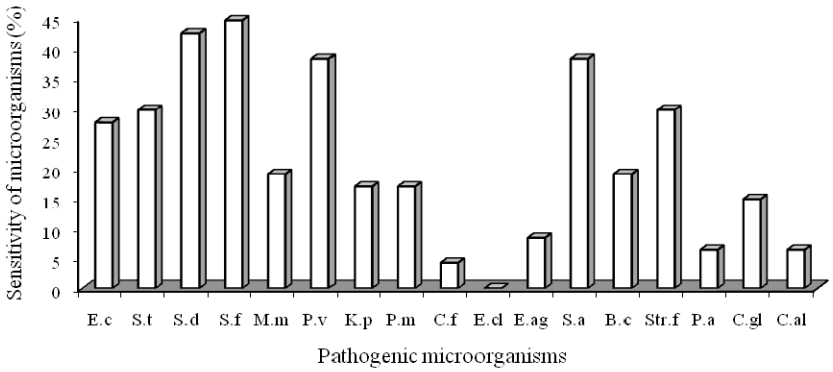

Figure 2. Sensitivity of microorganisms tested toward the plant extracts

E.c: *Escherichia coli*; S.t: *Salmonella typhi*; S.d: *Shigella dysenteriae*; S.f: *Shigella flexneri*; M.m: *Morganella morgani*; P.v: *Proteus vulgaris*; K.p: *Kebsiella pneumonia*; P.m: *Proteus mirabilis*; C.f: *Citrobacter freundii*; B.c: *Bacillus cereus*; En.c: *Enterobacter cloacae*; En.a: *Enterobacter agglomerans*; St.a: *Staphylococcus aureus*; St.f: *Streptococcus faecalis*; P.d: *Pseudomonas aeruginosa*; C.g: *Candida albicans*; C.a: *Candida glabrata*