

## Research Article

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# Antibacterial and antibiotic-potentiating activities of *Desmodium uncinatum*, *Neoboutonia glabrescens*, *Ternstroemia cameroonensis* and eight other Cameroonian medicinal plants against multi-drug resistant bacteria expressing active efflux pumps

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## Abstract

**Background:** Infectious diseases remain a major public health problem in the world with a considerable impact in developing countries. Bacterial infections are of increasing concern due to the emergence and spread of bacteria resistant to antibiotics. Thus, it is necessary to develop methods and means to tackle drug resistance. The present study aimed at evaluating the antibacterial and antibiotic-potentiating activities of eleven Cameroonian medicinal plants: *Sambucus nigra*, *Erigeron floribundus*, *Desmodium uncinatum*, *Neoboutonia glabrescens*, *Ficus exasperata*, *Sida rhombifolia*, *Echinaceae augustifolia*, *Centella asiatica*, *Tradescantia zebrina*, *Desmodium intortum* and *Ternstroemia cameroonensis* against bacteria with multidrug-resistant (MDR) phenotypes.

**Methods:** The microdilution method was used to assess the antibacterial activities of the extracts as well as the effect of their combination with antibiotics. The phytochemical screening of the extracts was carried out according to qualitative described methods.

**Results:** The phytochemical screening revealed the presence of tannins, triterpenes, polyphenols, and flavonoids in almost all the extracts, with the other classes of secondary metabolites being selectively distributed. The tested extracts exhibited variable antibacterial activities, with minimum inhibitory concentrations (MICs) ranging between 512 and 1024 µg/mL. The *Ficus exasperata* leaves extract, *Ternstroemia cameroonensis* bark extract, *Erigeron floribundus* whole plant extract, and *Neoboutonia glabrescens* leaf extracts, presented the best spectra of inhibitions evaluated respectively at 60%, 60%, 70%, and 70% vis-à-vis all the bacterial strains tested. The whole plant extracts of *Desmodium uncinatum* and *Centella asiatica*, and of *Ternstroemia cameroonensis* have shown synergistic effects with more than 50% of the antibiotics (chloramphenicol, tetracycline, kanamycin, ciprofloxacin, ofloxacin, azithromycin and erythromycin) against more than 70% of the MDR bacteria tested.

**Conclusion:** The present study demonstrated that extracts from the bark of *Ternstroemia cameroonensis*, *Neoboutonia glabrescens* and *Ficus exasperata* leaves, *Desmodium uncinatum*, and *Erigeron floribundus* whole plants can be used alone or in combination with antibiotics against bacterial infections involving MDR bacteria.

**Keywords:** Antibacterial; antibiotics; medicinal plants; multidrug resistance.

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## Background

The human or animal infection is its invasion by pathogens such as bacteria, parasites, viruses, or microscopic fungi. According to global health statistics reported by the World Health Organization (WHO), infectious diseases were responsible for 4.3 million deaths in 2016 [1]. Nowadays, they constitute a major public health problem as the fight against those diseases is becoming more and more difficult with the increased re-emergence of antibiotic-resistant microorganisms. Indeed, antibiotic resistance is the consequence of selection pressure on bacterial populations created by the massive use of antibiotics in human and animal health [2]. Antibiotic resistance has become one of the greatest threats to almost all countries in the world, including those in sub-Saharan Africa such as Cameroon. Resistant bacteria are already responsible for more than 700,000 deaths each year worldwide and in the next 35 years, the annual death rate could rise to 10 million [3]. In addition, the first antibiotic resistance surveillance data published by WHO showed high levels of resistance to several serious bacterial infections in both high- and low-income countries. The new WHO Global Antimicrobial Resistance Surveillance System reveals that antibiotic resistance affects 500,000 people with suspected bacterial infections in 22 countries [4]. Several biological and physiological mechanisms may be responsible for bacterial resistance, including enzymatic inactivation by disintegration or chemical modification of antibiotics, reduction of intracellular accumulation by decreasing influx and/or increasing efflux of antibiotics, and modification of cellular target sites [5,6,7,8]. The multidrug resistance observed in Gram-positive and Gram-negative bacteria is mostly attributed to the overexpression of efflux pumps and to the production of antibiotic-degrading enzymes in these bacteria. The pumps involved in this resistance mechanism are mainly Resistance-Nodulation-Division (RND) and Major Facilitator Superfamily (MFS) for Gram-positive and Gram-negative bacteria, respectively [9] which support several families of antibiotics. Because of this increasing resistance problem, the search for new effective antibacterial substances with low toxicity is a top priority. The Cameroonian flora abounds in plants and plant derivatives with diverse biological activities which have demonstrated their potential in the control of various human diseases, including bacterial infections [10-24]. Therefore, the exploration of this flora appears to be an interesting strategy in the discovery of new antibacterial drugs. In addition, several previous and recent works carried out in Cameroon have shown antibacterial activities and modulating effects on the antibiotic activity of extracts of many medicinal plants, food plants, and derived products against bacteria (Gram-positive and Gram-negative) sensitive or resistant / multi-resistant to common antibiotics [25-46].

In our continuous quest for new antibacterial substances from botanical sources, the present work was designed to evaluate *in vitro*, the antibacterial activity of methanolic extracts of eleven Cameroonian medicinal plants, namely *Sambucus nigra* L. (Caprifoliaceae), *Erigeron floribundus* (Kunth) Sch. Bip. (Asteraceae), *Desmodium uncinatum* (Jacq.) DC. (Fabaceae), *Ficus exasperata* Vahl. (Moraceae), *Sida rhombifolia* L. (Malvaceae), *Echinacea augustifolia* DC. (Asteraceae), *Centella asiatica* (L.) Urb. (Apiaceae), *Neoboutonia glabrescens* Prain. (Euphorbiaceae), *Desmodium intortum* (Mill.) Urb. (Fabaceae), *Tradescantia zebrina* hort. ex Bosse. (Commelinaceae) and *Ternstroemia cameroonensis* Cheek (Ternstroemiaceae). This study was extended to the evaluation of the capacity of some

extracts studied to potentiate the activity of commonly used antibiotics against resistant strains. The plants used in this study are commonly used in traditional medicine in the treatment of many diseases which include, bacterial and fungal infections.

## Methods

### Plant material and extraction

The eleven medicinal plants used in this work were collected in Douala (Littoral region, Cameroon), Dschang, and Mbouda (West region, Cameroon) from October to December 2019. Plant samples collected were the leaves, fruits, and barks of *Ternstroemia cameroonensis*, the whole plant of *Erigeron floribundus*, *Sambucus nigra*, *Desmodium uncinatum*, *Centella asiatica*, *Tradescantia zebrina*, and *Desmodium intortum*, the leaves of *Neoboutonia glabrescens*, *Ficus exasperata* and *Sida rhombifolia* and the roots of *Echinacea augustifolia*. Plants were identified at the National Herbarium (Yaoundé, Cameroon) where reference specimens were deposited under reference numbers (Table 1). Each plant sample was air-dried at laboratory temperature ( $22 \pm 2^\circ\text{C}$ ) and then powdered. The resulting powder was extracted with methanol (1:3 w/v) for 48 hours at room temperature. The preparation was stirred three times a day, after which it was filtered through Wattman No. 1 filter paper. The filtrate obtained was concentrated under reduced pressure (at  $40^\circ\text{C}$ ) in a rotary evaporator (BÜCHI R-200) to give the corresponding crude extracts which were dried at room temperature for complete evaporation of methanol. All extracts were then stored at  $4^\circ\text{C}$  until further use. The extraction yields (Table 2) of each sample were obtained by the formula, extraction yields = (weight of crude extract/weight of powder) x100.

### Chemicals for antimicrobial assay

Twelve antibiotics (ATB) of different classes, including the betalactams (cloxacillin (CLO) and Flucloxacillin, (FLU)), cyclins (tetracycline (TET) and doxycycline (DOX)), aminoglycosides (kanamycin (KAN) and gentamycin (GEN)) macrolides (erythromycin (ERY) and azitromycin (AZT)), phenicol's (chloramphenicol (CHL) and thiamphenicol (THI)), quinolones (ciprofloxacin (CIP) and ofloxacin (OFL)), have been used. They were prepared in MHB. Dimethylsulfoxide (DMSO) was used to dissolve the tested samples. The microbial growth indicator used was p-iodonitrotetrazolium chloride  $\geq 97\%$  [47]. All these chemicals were supplied by Sigma-Aldrich (St. Quentin Fallavier, France).

### Bacterial strains and culture media

The microorganisms used were multidrug-resistant (MDR) bacteria, phenotypes involved in microbial infections, and expressing efflux pumps. These bacteria consisted of a panel of 20 bacteria (Gram-negative and Gram-positive). They included resistant strains of *Escherichia coli*, *Enterobacter aerogenes*, *Klebsiella pneumoniae*, *Providencia stuartii*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. These bacterial strains were provided by the American Type Culture Collection (ATCC) and the laboratory of UMR-MD1 of the *Université de la Méditerranée*, Marseille, France. Their bacterial characteristics were previously given (Additional file 1; Table S1) [27, 46]. Bacterial strains were maintained on agar plates at  $4^\circ\text{C}$  and subcultured onto appropriate fresh agar plates 24 hours before any antibacterial testing. Mueller Hinton agar (MHA;

Sigma) was used for bacterial activation and Mueller Hinton broth (MHB; Sigma) was used for minimum concentration [48] and modulation factor determination [49].

#### Antibacterial assays

The determination of the pharmacological parameters: the minimum inhibitory concentration (MIC) and the minimum bactericidal concentration (MBC) on the tested bacterial strains were performed using a rapid colorimetric test with piodonitrotetrazolium chloride (INT) [47, 50]. The different plant extracts and the reference drug were dissolved in DMSO-MHB. The bacterial inoculum used was  $1.5 \times 10^6$  CFU/mL and the incubation conditions were 37°C and 18 hours. DMSO at less than 2.5% was used as a control solvent while CHL was used as a positive control. A preliminary test was performed by evaluating a combination of the plant extracts at different sub-inhibitory concentrations (MIC/2, MIC/4, MIC/8, and MIC/16) with 12 antibiotics (CLO, FLU, TET, DOX, KAN, GEN, ERY, AZT, CHL, THI, CIP, and OFL) on *Pseudomonas aeruginosa* PA124 (see Additional file 1; Table S2), which allowed us to select the appropriate sub-inhibitory concentration to further potentiate the effect on other bacteria. Therefore, MIC/2 and MIC/4 values were subsequently used for the combination of antibiotics in the sample on a larger number of bacteria [34 - 37]. The effects of the combination were evaluated by calculating the improvement activity factors (IAF) of each combination using the following formula: MIC of the antibiotic alone / MIC of the combination (Tables 4-9). Each test was performed in triplicate and twice independently. The extract and antibiotic were considered to have synergistic, indifference, or antagonistic effects if  $IAF \geq 2$ ,  $IAF = 1$  or  $IAF \leq 0.5$  respectively [51].

#### Phytochemical screening

The presence of the major classes of secondary metabolites, namely alkaloids, polyphenols, flavonoids, triterpenes, steroids, anthraquinones, anthocyanins, tannins, and saponins (Table 2) was determined using the standard phytochemical methods described by Harbone [52].

## Results

#### Phytochemical composition

The results in Table 2 reporting the phytochemical screening of the plant extracts showed that the secondary metabolite classes are selectively distributed in the extracts of the plants studied. Except for the anthocyanin class, all other secondary metabolite classes sought were present in the *Neoboutonia glabrescens* leaf extract. Moreover, except for the extracts of *Echinacea augustifolia* roots, *Centella asiatica* and *Desmodium intortum* whole plants, *Ternstroemia cameroonensis* leaves, bark, and fruits, all the other plant extracts contain an average of six (6) of the nine (9) secondary metabolites highlighted during this screening. However, most of them (extracts of bark and leaves of *Ternstroemia cameroonensis*, extract of the whole plant of *Desmodium intortum*) contain secondary metabolites of interest such as polyphenols and terpenoids (Table 2).

#### Antibacterial activity

The MIC results as compiled in Table 3 show that the tested plant extracts possess varied antibacterial activities, with MICs generally ranging from 512 to 1024  $\mu\text{g/mL}$ . Extracts from the whole plant of *Erigeron floribundus* and from the leaves of *Neoboutonia glabrescens* showed the highest activity spectra (active on 70% of the bacterial strains tested), followed by extracts from the leaves of *Ficus exasperata*, bark, and leaves of *Ternstroemia cameroonensis* (active on 60%, 60% and 40% of the bacterial strains tested respectively). The other plant extracts showed activities that varied from one bacterial species to another. Most extracts exhibited MBC/MIC ratios  $\leq 2$  on most of the tested strains. CHL was used as a reference antibiotic on the tested bacteria (Gram-negative and Gram-positive). It was active on all (100%) of the bacteria tested with MICs ranging from 16  $\mu\text{g/mL}$  to 128  $\mu\text{g/mL}$ .

#### Potentiating effect of crude extracts

Based on the results obtained in a preliminary study performed on *Pseudomonas aeruginosa* PA124, the six selected plant extracts (*Desmodium uncinatum*, *Centella asiatica*, *Neoboutonia glabrescens* leaves and *Ternstroemia cameroonensis*, fruits and bark of *Ternstroemia cameroonensis*) were combined with twelve antibiotics (CLO, FLU, TET, DOX, KAN, GEN, ERY, AZT, CHL, THI, CIP, and OFL) commonly used in bacterial chemotherapy in order to verify their ability to potentiate the activities of these latter. Tables 4-9 show that the selected extracts potentiated the effect of the antibiotics in varying proportions depending on the antibiotic and the bacterial strain at the sub-inhibitory concentrations of MIC/2 and MIC/4. At MIC/2 concentration, all extracts except *Ternstroemia cameroonensis* fruits potentiated the activity of at least 50% (6/12) of the antibiotics used in this combination test on a percentage of at least 63% (7/11) of the tested bacterial strains. Numerous cases of synergy were observed with improvement activity factors generally between 2 and 16. The extracts of *Desmodium uncinatum* and *Neoboutonia glabrescens* leaves were the ones that presented the highest levels of antibiotic potentiation. These extracts potentiated more than 72% (8/11) of the antibacterial activities of all the antibiotics used except THI (both extracts); ERY and OFL (*Desmodium uncinatum* extract only); with a percentage of activity improvement of 100% (11/11) with CLO (*Desmodium uncinatum* extract); CHL, ERY and OFL (*Neoboutonia glabrescens* leaves extract). Other interesting effects were also observed with, for example, *Centella asiatica* extract which potentiated the activities of CHL, FLU, TET, and AZI on more than 90%, 81%, 81%, and 90% of the bacterial strains tested respectively. In general, all ATBs showed improved antibacterial activities in the presence of at least one extract against at least one of the tested strains. Several cases of indifference and antagonism were also observed.

## Discussion

The biological activity of natural substances depends on the active principle (secondary metabolites) they contain [53, 54]. This activity depends not only on the presence of secondary metabolites alone but also on their types, their quantity, and possible interactions with other constituents. These parameters can vary from one plant to another but also from one part to another in the same plant and

depends on the harvest period. The phytochemical screening carried out in the framework of this study allowed us to put forth the presence of various classes of secondary metabolites recognized essentially for their antimicrobial properties as highlighted by the work of many authors [55-57].

The tested plant extracts showed different antibacterial activities varying from one extract to another, whose MICs were assessed according to the classification scale of antibacterial activities of medicinal plant extracts established by Kuete et al. [10]. Based on this scale, a medicinal plant extract or an extract of a part of a medicinal plant is considered significantly active when it has a MIC < 100 µg/mL, moderately active when 100 < MIC ≤ 625 µg/mL, and weakly active when its MIC > 625 µg/mL. consistently with this, several plant extracts were found to be moderately active against some bacterial strains tested while weakly active against others. The whole plant extract of *Desmodium uncinatum* was found to be moderately active against *E. coli* AG102, ATCC 10536, ATCC 8739, and *S. aureus* MRSA12 and ATCC25923. These results corroborate to some extent the work of Hisako et al. [58] on a plant of the same genus (*Desmodium caudatum*) and revealed the antistaphylococcal potential of the products isolated from this plant against susceptible (MSSA) and resistant (MRSA) strains. Furthermore, the study of Baloyi et al. [59] on leaf and stem extracts of *Desmodium uncinatum* had revealed the presence of tannins and saponins as highlighted during phytochemical screening of the whole plant extract of *Desmodium uncinatum* that was done in the present study. However, the studies of Scarbert [60] and Rodrigues et al. [61] have highlighted the important antibacterial activity of tannins, the mechanism of which would be the action on the metabolism of the bacterial cell, especially by inhibition of the enzymes of oxidative phosphorylation of the electron transport system, the inactivation of adhesins and proteins of the cell envelope.

The extract of *Neoboutonia glabrescens* leaves showed moderate activity against *E. coli* AG100, *P. stuartii* ATCC 29916, and *S. aureus* MRSA12 and MRSA9. The work of Tchinda et al. [62] carried out on the stem bark of *Neoboutonia glabrescens* allowed the isolation of several compounds such as glabrescin, a diterpenoid daphnane, neobutonin and phenolic compounds which have shown antimicrobial properties. The fruits and leaves extracts of *Ternstroemia cameroonensis* showed moderate activity against *E. coli* AG100Atet and *E. aerogenes* EA27; and, against *S. aureus* MSSA1 and *K. pneumoniae* KP55 for fruits and leaves respectively. The phytochemical study by Balderas-lopez et al. [63] on a species of the same genus as *Ternstroemia cameroonensis* revealed the presence of classes of secondary metabolites like those we obtained: tannins (leaves), triterpenes (leaves) and saponins (barks). It should be noted, however, that the work of Cowan [25] already highlighted the antibacterial properties of the classes of secondary metabolites detected in *Ternstroemia cameroonensis*.

The extracts from the whole plant of *Erigeron floribundus* and the leaves of *Ficus exasperata* were moderately active against *E. coli* AG100A and *S. aureus* MSSA1 respectively. These plants are traditionally used in the treatment of diseases of microbial and non-microbial origin [64], *Erigeron floribundus* is a plant whose leaf decocts showed antibacterial activity against *S. aureus* and *E. coli* strains in work carried out by Etchikié et al. [65], which

corroborates the results obtained in this work. At the same time, the work carried out by Petrelli et al. [66] showed the antibacterial activity of the essential oil of *Erigeron floribundus*, due to the presence of triterpenes.

The investigations of Taiwo et al. [67] on the methanolic extract of *Ficus exasperata* leaves revealed its antibacterial potential towards *S. aureus*, which corroborates the results obtained in the present study. Moreover, the authors attributed this activity to the presence of polyphenols that we also found in the extract of *Ficus exasperata* leaves.

It should be noted that other extracts such as those of *Sambucus nigra* leaves, *Sida rhombifolia* whole plant, the roots of *Echinacea augustifolia*, *Centella asiatica*, and *Desmodium intortum* whole plants showed weak activities against some of the tested bacterial strains. The absence or low activity of these extracts could be attributed either to the multi-resistant character of the tested bacterial strains or to the difficulties that could hinder the accessibility of the active principle(s) to its target.

According to Mbaveng et al. [68], when the MBC/MIC activity ratio of an antimicrobial substance is less than or equal to four (≤4), the latter is qualified as a bactericidal substance, whereas if this ratio is greater than four (>4), it is said to be bacteriostatic. Many plant extracts that were evaluated in this work for their antibacterial activities were bactericidal against at least one bacterial strain.

Synergistic or modulating effects following the association of the selected plant extracts (*Desmodium uncinatum*, *Centella asiatica*, leaves of *Neoboutonia glabrescens* and *Ternstroemia cameroonensis*, fruits and bark of *Ternstroemia cameroonensis*) with the antibiotics towards the tested bacteria have been noted. The extracts of *Desmodium uncinatum* and *Neoboutonia glabrescens* leaves were the ones with the highest levels of antibiotic potentiation. These extracts have indeed at the concentration of MIC/2 potentiated more than 72% (8/11) in addition to the antibacterial activities of all the tested antibiotics except THI (both extracts) and ERY and OFL (*Desmodium uncinatum* extract). In addition, these two (02) extracts showed a percentage improvement of 100% (11/11) activity with CLO (*Desmodium uncinatum* extract), CHL, ERY, and OFL (*Neoboutonia glabrescens* leaf extract). Other synergistic effects were also observed with *Centella asiatica* extract which potentiated the activities of OFL, CHL, FLU, TET, and AZI on more than 90%, 81%, 81%, 90% of the tested strains respectively. According to the potentiation percentages, these extracts would contain substances capable of inhibiting the efflux pumps overexpressed by the multidrug-resistant bacteria tested [69]; or the simultaneous actions of the active principle(s) of these extracts and the antibiotics would have taken place at different sites. Numerous cases of indifference were also observed, and this could be due to the absence, in the tested extracts of compounds absence in the extracts tested the compounds capable of blocking the efflux pumps through which the bacteria expel the antibiotics or to the fact that the active principles contained in these extracts had no direct effect on the mechanisms developed by the bacteria to resist the action of the antibiotic. Some cases of antagonism have also been observed and this could be explained by the fact that there may have been neutralization between some of the active principles of the extract and the antibiotic [33].

**Table 1.** Information on the studied plants

Plant species (family); voucher number	Traditional uses	Bioactive or potentially bioactive components	Bioactivity of crude extract
<i>Sambucus nigra</i> L. (Caprifoliaceae) ; /	Used for the prevention and treatment of common illnesses such as the Common Cold, swollen joints, and rheumatic pain [70]; The roots and leaves are used for the treatment of wounds, eczema, and hives [71].	Contains compounds such as flavonoids (routine, coercetin, isocoercetin, astragalol), phenolic acids, vitamins A and C (in fruit), anthocyanins and volatile matter [72].	Standardized liquid extract: Sp, Bc group C and G streptococci [73]; Flower extract: As, Fp, Va, Vo, Ec [74].
<i>Erigeron floribundus</i> (H.B et K) Sch. Bip (Asteraceae) ; 5619 /SRFCam	Used to treat sore throat, female infertility [75]; AIDS, dental pain, headaches, and various diseases of microbial and non-microbial origin [56]; treatment of hypo-acidities, gastric hyperacidity, and angina [76].	Polyphenols, triterpenes [77]; sesquiterpene hycarbons [78].	Leaf decoction: Sa, Ec [65].
<i>Desmodium uncinatum</i> DC (Fabaceae) ; 42666/ HNC	Decoctions of dried leaves and flowers are used to treat worms, yellow fever, diarrhoea, toothache [79].	Contains: genistein, uncinanone A, uncinanone B, uncinanone C [80], uncinanone D and uncinanone E [81]; contains tannins and saponins [59].	The aqueous and methanolic extract of <i>Desmodium triflorum</i> (plant of the same genus): Sa, Me, Bp, Pa, Pf, Ec [80]
<i>Neoboutonia glabrescens</i> (Euphorbiaceae) ; /	Used in the treatment of malaria [82].	Glabrescine, a diterpenoid daphnane, neobutonine, a degraded diterpenoid with a new skeleton, and neoglabrescines A and B, both derivatives of rhamnofolan and phenolic compounds [62].	Methanol extract of <i>Neoboutonia macrocalyx</i> (plant of the same genus): Ca, Mm [83]; Ethanolic extract: Pf [82].
<i>Ficus exasperata</i> (Moraceae) ; 10084 SRFcam	Used to treat stings and bites of scorpion, snake and wasp (its flowers), skin diseases and wounds (its stem) [84]; Used for poultice of ulcers, herpes, fever, hemorrhoids and all kinds of inflammations [85].	Oxidative lignans in leaf extracts [86]; bergapten and oxypeucedanine hydrate in stem bark; sitosterol and sitosterol-3-O- $\beta$ -D-glucopyranoside in leaves [87]	Methanolic extract: Ec, Sa, Pa, Bs, Cp [67].
<i>Sida rhombifolia</i> Linn. (Malvaceae) ; 57789/HNC	Used to treat stings and bites of scorpion, snake, and wasp (its flowers), skin diseases and wounds (its stem) [84]; Used for poultice of ulcers, herpes, fever, haemorrhoids, and all kinds of inflammations [85].	The aqueous methanol extract indicates the presence of terpenoids, alkaloids, quinine, polyphenols, and flavonoids [88].	Methanol, chloroform, petroleum ether extract: Sa, Ec, Ps, St [89]; Aqueous ethanol extract: Kp, C, St, Sa [88].
<i>Echinaceae augustifolia</i> D.C (Asteraceae); BR0000022728135	Strengthens the immune system, treats infections related to lung diseases and respiratory tract infections such as bronchitis, pharyngitis, nasopharyngitis [90].	Polysaccharides (arabinogalactan, xyloglycan, echinacin), glycosides: caffeic acid and its derivatives (cichoric acid, echinacoside), alkaloids, alkylamides, polyacetylenes and other fatty acids [91].	The root extract: Ps, Ec [92].
<i>Centella asiatica</i> (Linn) urb (Apiaceae) ; 5430/SRFK	Used to treat wounds, mental, and neurological disorders, diarrhoea, asthma, ulcers, tuberculosis, and some skin conditions [93].	Dichloromethane/methanolic extract reveals the presence of alkaloids, flavonoids, phenolics, terpenoids, cardiac glycosides, saponins, and tannins [93].	Essential oil: Se, Pa, Ca [94]; Dichloromethane/methanolic extract: Ec, St, Sa, Bs, Ss [85].
<i>Tradescantia zebrina</i> (commelinaceae) ; /	Treatment of mycotic infections [95]; gastrointestinal disorders and cancer [96].	Phenols, tannins, flavonoids [97].	Leaf extract: Bc, Bs, MI, Sa, Se, Ef, Ah, Pv [93].
<i>Desmodium intortum</i> urb.(Fabaceae); 53255 HNC	Strengthens the immune system, treats infections related to lung diseases and respiratory tract infections such as bronchitis, pharyngitis, nasopharyngitis [90].	Polysaccharides (arabinogalactan, xyloglycan, echinacin), glycosides: caffeic acid and its derivatives (cichoric acid, echinacoside), alkaloids, alkylamides, polyacetylenes and other fatty acids [90].	The root extract: Ps, Ec [91].
<i>Ternstroemia cameroonensis</i> (Ternstroemiaceae); /	<i>Ternstroemia</i> species are for the treatment of nerves, depression, and anxiety [98].	Phytochemical studies of <i>Ternstroemia</i> species have reported the isolation of oleanane and ursane triterpenoids, triterpenoid glycosides, triterpenoid saponins, carotenoids, monoterpenoids, tannins [99].	Sedative effect of aqueous extracts of pericarp or fruit seeds of <i>T. sylvatica</i> (plant belonging to the same genus as <i>T. cameroonensis</i> ) [99].

/ : not reported ; HNC: Cameroon National Herbarium; SRF/Cam/ K : Section des Réserves Forestières du Cameroun / Kamerun ; Sp : *Streptococcus pyogenes* ; Bc : *Branhamella catarrhalis* ; As : *Aeromonas salmonicida* ; Fp : *Flavobacterium psychrophilum* ; Va : *Vibrio anguillarum* ; Vo : *Vibrio ordalii* ; Ec : *Escherichia coli* ; Sa : *Staphylococcus aureus* ; Me : *Micrococcus luteus* ; Bp : *Bacillus pumilus* ; Pa : *Pseudomonas aeruginosa* ; Pf : *Pseudomonas fluorescens* ; Ca : *Candida albicans* ; Mm : *Mucus michei* ; Bs : *Bacillus subtilis* ; Cp : *Candida pseudotropicalis* ; Ps : *Pseudomonas syringae* ; St : *Salmonella typhi* ; Kp : *Klebsiella pneumonia* ; C : *Citrobacter*. Se : *Staphylococcus epidermidis* ; Ss : *Shigella sonnei* ; Bc : *Branhamella catarrhalis* ; MI : *Micrococcus luteus* ; Ef : *Enterococcus faecalis* ; Ah : *Aeromonas hydrophila* ; Pv : *Proteus vulgaris*.

**Table 2.** Phytochemical composition of the plant extracts

Classes	Studied plants (% yield) * and composition																					
	TC		SN		EF		DU		NG		FE		SR		EA		CA		TZ		DI	
	L (16%)	F (15.83 %)	B (22.5 %)	W (5.65%)	W (8.95%)	W (11.79%)	L (22.61%)	L (7.24%)	L (8.81%)	R (9.75%)	W (15.08 %)	W (5.72%)	W (8.77%)									
Alkaloids	-	-	-	-	-	-	+	-	-	-	+	-	+									
Polyphenols	+	-	+	+	-	-	+	+	+	-	-	+	+									
Flavonoids	+	+	+	+	+	+	+	+	+	+	+	-	+									
Anthraquinones	-	-	+	-	+	-	+	+	+	-	-	+	-									
Anthocyanins	-	-	+	-	+	+	-	+	-	+	+	+	+									
Tannins	+	-	-	+	-	+	+	+	+	-	-	+	-									
Triterpenes	+	-	-	+	+	+	+	+	+	+	+	+	-									
Steroids	+	-	-	+	+	+	+	-	-	-	-	+	-									
Saponins	-	+	+	+	+	+	+	+	+	-	+	+	+									

TC: *Temstroemia cameroonensis*; SN: *Sambucus nigra*; EF: *Erigeron floribundus*; DU: *Desmodium uncinatum*; NG: *Neoboutonia glabrescens*; FE: *Ficus exasperata*; SR: *Sida rhombifolia*; EA: *Echinacea augustifolia*; CA: *Centella asiatica*; TZ: *Tradescantia zebrina*; DI: *Desmodium Intortum*; (-): Absent; (+): Present; \* yield calculated as the ratio of the mass of the obtained methanol extract/mass of the plant powder; The tested extracts were obtained from L: Leaves; B: bark; F: Fruit; R: Root; W: whole plant.

**Table 3.** MICs and MBCs in µg/mL of methanol extracts from the studied plants and chloramphenicol

Bacterial strains	Tested samples, MIC, and MBC (in bracket) values (µg/mL)																								
	TC		SN			EF		DU		NG		FE		SR		EA		CA		TZ		DI		ATB	
	L	F	B	W	W	W	L	L	L	R	W	W	W	W	W	W	W	W	W	W	W	W	W	W	CHL
<b><i>Escherichia coli</i></b>																									
ATCC8739	- (-)	- (-)	1024 (-)	1024 (-)	1024 (-)	512 (1024)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	32 (128)
ATCC10536	- (-)	- (-)	- (-)	1024 (-)	1024 (-)	512 (512)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	32 (64)
AG100 <sup>TET</sup>	-512(-)	512 (-)	- (-)	- (-)	512 (1024)	- (-)	1024 (-)	1024 (1024)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	32 (64)
AG102	- (-)	- (-)	- (-)	- (-)	1024 (-)	512 (512)	1024 (-)	1024 (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	64 (256)
AG100	1024 (-)	- (-)	512 (-)	- (-)	- (-)	- (-)	512 (-)	1024 (1024)	1024 (-)	1024 (-)	1024 (1024)	1024 (-)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	128 (256)	
<b><i>Enterobacter aerogenes</i></b>																									
ATCC13048	1024 (-)	1024 (-)	1024 (-)	- (-)	- (-)	- (-)	1024 (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	16(64)
EA27	512 (-)	512 (-)	- (-)	1024 (-)	1024 (-)	1024 (-)	- (-)	1024 (1024)	- (-)	1024 (-)	1024 (-)	1024 (1024)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	- (-)	1024 (1024)	1024 (256)	
<b><i>Klebsiella pneumoniae</i></b>																									
KP55	512 (-)	1014 (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	32 (164)
KP63	- (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	- (-)	1024 (-)	1024 (-)	- (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	32 (128)
K24	- (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	1024 (-)	- (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	64 (128)
<b><i>Providencia stuartii</i></b>																									
NEA16	- (-)	- (-)	- (-)	- (-)	1024 (-)	1024 (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	64 (256)
ATCC29916	- (-)	- (-)	1024 (-)	1024 (-)	1024 (1024)	- (-)	512 (1024)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	64 (128)
<b><i>Pseudomonas aeruginosa</i></b>																									
PA01	1024 (-)	- (-)	- (-)	- (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	32 (64)
PA124	- (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	128 (256)
<b><i>Staphylococcus aureus</i></b>																									
ATCC25923	- (-)	- (-)	1024 (-)	- (-)	- (-)	512 (512)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	16 (64)
MRSA3	- (-)	- (-)	- (-)	- (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	64 (256)
MRSA6	- (-)	- (-)	1024 (-)	- (-)	- (-)	- (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	64 (128)
MRSA9	1024 (-)	- (-)	- (-)	- (-)	1024 (-)	- (-)	512 (-)	- (-)	- (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	1024 (-)	64 (256)
MRSA12	- (-)	- (-)	1024 (-)	- (-)	1024 (1024)	512 (1024)	512 (-)	512 (-)	1024 (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	128 (256)
MSSA1	1014 (-)	512 (-)	1024 (-)	1024 (-)	- (-)	- (-)	1024 (-)	512 (-)	- (-)	- (-)	- (-)	1024 (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	1024 (-)	- (-)	128 (256)

- : >1024 (MIC) or not determined; *Ternstroemia cameroonensis*: TC; *Sambucus nigra*: SN; *Erigeron floribundus*: EF; *Desmodium uncinatum*: DU; *Neoboutonia glabrescens*: NG; *Ficus Exasperata*: FE; *Sida rhombifolia*: SR; *Echinacea augustifolia*: EA; *Centella asiatica*: CA; *Tradescantia zebrina*: TZ; *Desmodium Intortum*: DI; the tested extracts were obtained from (L: Leaves; B: bark; F: Fruit; R: Root; W: whole plant); ATB: antibiotic; CHL: chloramphenicol.

**Table 4.** MIC values ( $\mu\text{g/mL}$ ) of antibiotics in the presence of *Desmodium uncinatum* whole plant extract and IAF values

Antibiotics	Concentration of extract	Bacterial strains and isolates											Modulation effect of antibiotic (%)
		<i>E. coli</i>		<i>E. aerogenes</i>		<i>P. stuartii</i>		<i>K. pneumoniae</i>		<i>S. aureus</i>		<i>P. aeruginosa</i>	
		AG100 Atet	ATCC 10536	EA27	ATCC 13048	NEA16	ATCC 29916	KP55	KP63	ATCC 25923	MRSA9	PA124	
ERY	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	2(0.25)	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>63.63</b>
	MIC/4	<b>1(2)</b>	2(1)	8(0.25)	2(1)	8(0.25)	<b>1(2)</b>	2(1)	4(0.5)	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>27.27</b>
GEN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>72.72</b>
	MIC/4	<b>1(2)</b>	4(0.5)	2(1)	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	2(1)	2(1)	2(1)	4(0.5)	$\geq 8$ (nd)	<b>27.27</b>
THI	0	4	4	4	4	4	4	4	4	4	4	4	
	MIC/2	<b>0.5(8)</b>	<b>2(0.5)</b>	<b>2(2)</b>	<b>1(4)</b>	<b>2(2)</b>	<b>0.5(8)</b>	<b>1(4)</b>	4(1)	<b>2(2)</b>	4(1)	<b>0.5(8)</b>	<b>45.45</b>
	MIC/4	<b>1(4)</b>	8(0.5)	4(1)	4(1)	4(1)	<b>1(4)</b>	<b>2(2)</b>	8(0.5)	4(1)	8(0.5)	$\geq 16$ (nd)	<b>18.18</b>
OFL	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	$\geq 8$ (nd)	<b>63.63</b>
	MIC/4	2(1)	2(1)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	4(0.5)	4(0.5)	2(1)	<b>1(2)</b>	$\geq 8$ (nd)	<b>18.18</b>
CHL	0	256	256	256	256	256	256	256	256	256	256	256	
	MIC/2	<b>64(4)</b>	<b>64(4)</b>	<b>128(2)</b>	<b>128(2)</b>	<b>128(2)</b>	<b>64(4)</b>	256(1)	<b>128(2)</b>	<b>64(4)</b>	<b>64(4)</b>	<b>64(4)</b>	<b>90.90</b>
	MIC/4	<b>128(2)</b>	256(1)	256(1)	256(1)	256(1)	<b>128(2)</b>	512(0.5)	256(1)	<b>128(2)</b>	<b>128(2)</b>	<b>64(4)</b>	<b>45.45</b>
CIP	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	2(1)	<b>81.81</b>
	MIC/4	2(1)	<b>1(2)</b>	2(1)	2(1)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>36.36</b>
FLU	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>72.72</b>
	MIC/4	<b>1(2)</b>	4(0.5)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	2(1)	4(0.5)	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>36.36</b>
CLO	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.25(8)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>100</b>
	MIC/4	<b>1(2)</b>	2(1)	2(1)	2(1)	2(1)	<b>0.5(4)</b>	2(1)	2(1)	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>36.36</b>
TET	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	2(1)	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.25(8)</b>	<b>72.72</b>
	MIC/4	<b>1(2)</b>	4(0.5)	4(0.5)	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	2(1)	4(0.5)	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>45.45</b>
KAN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.25(8)</b>	<b>90.90</b>
	MIC/4	<b>1(2)</b>	<b>1(2)</b>	2(1)	2(1)	2(1)	<b>1(2)</b>	2(1)	4(0.5)	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>45.45</b>
DOX	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.25(8)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>81.81</b>
	MIC/4	2(1)	<b>1(2)</b>	4(0.5)	2(1)	2(1)	<b>1(2)</b>	2(1)	4(0.5)	2(1)	2(1)	2(1)	<b>18.18</b>
AZI	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>81.81</b>
	MIC/4	<b>1(2)</b>	2(1)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	2(1)	2(1)	<b>36.36</b>

MIC : Minimum Inhibitory Concentration ; ERY : Erythromycin; GEN: Gentamycin; THI: Thiamphenicol; OFL: Ofloxacin; CHL: Chloramphenicol; CIP: Ciprofloxacin; FLU: Flucloxacillin; CLO: Cloxacillin; TET: Tetracycline; KAN: Kanamycin; DOX: Doxycycline; AZI: Azithromycin; ( ) : IAF ( Improvement activity factor).



**Table 5.** MIC values ( $\mu\text{g/mL}$ ) of antibiotics in the presence of *Neoboutonia glabrescens* leaves extract and IAF values

Antibiotics	Concentration of extract	Bacterial strains and isolates											Modulation effect of antibiotic (%)
		<i>E. coli</i>		<i>E. aerogenes</i>		<i>P. stuartii</i>		<i>K. pneumoniae</i>		<i>S. aureus</i>		<i>P. aeruginosa</i>	
		AG100 Atet	ATCC 10536	EA27	ATCC 13048	NEA1 6	ATCC 29916	KP55	KP63	ATCC 25923	MRSA9	PA124	
ERY	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>100</b>
	MIC/4	2(1)	<b>1(2)</b>	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>63.63</b>
GEN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(1)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	<b>81.81</b>
	MIC/4	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	4(0.5)	2(1)	4(0.5)	<b>1(2)</b>	<b>63.63</b>
THI	0	4	4	4	4	4	4	4	4	4	4	4	
	MIC/2	2(2)	<b>1(4)</b>	<b>1(4)</b>	2(2)	<b>1(4)</b>	<b>0.25(16)</b>	<b>1(4)</b>	<b>1(4)</b>	<b>1(4)</b>	2(2)	<b>0.25(16)</b>	<b>72.72</b>
	MIC/4	4(1)	2(2)	2(2)	4(1)	2(2)	<b>0.5(4)</b>	2(2)	2(2)	2(2)	4(1)	<b>0.5(4)</b>	<b>18.18</b>
OFL	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.125(16)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.125(16)</b>	<b>100</b>
	MIC/4	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>81.81</b>
CHL	0	256	256	256	256	256	256	256	256	256	256	256	
	MIC/2	<b>128(2)</b>	<b>64(4)</b>	<b>64(4)</b>	<b>64(4)</b>	<b>64(4)</b>	<b>32(8)</b>	<b>128(2)</b>	<b>64(4)</b>	<b>32(8)</b>	<b>128(2)</b>	<b>16(16)</b>	<b>100</b>
	MIC/4	256(1)	<b>128(2)</b>	<b>128(2)</b>	<b>128(2)</b>	<b>128(2)</b>	<b>64(4)</b>	256(1)	<b>128(2)</b>	<b>64(4)</b>	256(1)	<b>32(8)</b>	<b>72.72</b>
CIP	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.125(16)</b>	<b>90.90</b>
	MIC/4	4(0.5)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>72.72</b>
FLU	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>90.90</b>
	MIC/4	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>63.63</b>
CLO	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.125(16)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	4(0.5)	<b>90.90</b>
	MIC/4	2(1)	<b>1(2)</b>	2(1)	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>54.54</b>
TET	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.125(16)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>90.90</b>
	MIC/4	<b>1(2)</b>	<b>1(2)</b>	2(1)	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>63.63</b>
KAN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	4(0.5)	<b>90.90</b>
	MIC/4	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	2(1)	2(1)	$\geq 8$ (nd)	<b>54.54</b>
DOX	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	$\geq 8$ (nd)	<b>90.90</b>
	MIC/4	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>54.54</b>
AZI	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	8(0.25)	<b>90.90</b>
	MIC/4	2(1)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	2(1)	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>45.45</b>

MIC : Minimum Inhibitory Concentration ; ERY : Erythromycin; GEN: Gentamycin; THI: Thiamphenicol; OFL: Ofloxacin; CHL: Chloramphenicol; CIP: Ciprofloxacin; FLU: Flucloxacillin; CLO: Cloxacillin; TET: Tetracycline; KAN: Kanamycin; DOX: Doxycycline; AZI: Azithromycin; ( ) : IAF ( Improvement activity factor).

**Table 6.** MIC values ( $\mu\text{g/mL}$ ) of antibiotics in the presence of *Centella asiatica* whole plant extract and IAF values

Antibiotics	Concentration of extract	Bacterial strains and isolates											Modulation effect of antibiotic (%)
		<i>E. coli</i>		<i>E. aerogenes</i>		<i>P. stuartii</i>		<i>K. pneumoniae</i>		<i>S. aureus</i>		<i>P. aeruginosa</i>	
		AG100 Atet	ATCC 10536	EA27	ATCC 13048	NEA16	ATCC 29916	KP55	KP63	ATCC 25923	MRSA9	PA124	
ERY	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>1(2)</b>	4(0.5)	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>54.54</b>
	MIC/4	2(1)	2(1)	8(0.25)	<b>1(2)</b>	8(0.25)	2(1)	2(1)	4(0.5)	2(1)	4(0.5)	$\geq 8$ (nd)	<b>09.09</b>
GEN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	4(0.5)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>63.63</b>
	MIC/4	<b>1(2)</b>	2(1)	4(0.5)	<b>1(2)</b>	8(0.25)	2(1)	2(1)	4(0.5)	2(1)	4(0.5)	$\geq 8$ (nd)	<b>18.18</b>
THI	0	4	4	4	4	4	4	4	4	4	4	4	
	MIC/2	<b>2(2)</b>	4(1)	2(0.5)	<b>0.5(8)</b>	8(0.5)	<b>1(4)</b>	<b>2(2)</b>	4(1)	<b>2(2)</b>	<b>2(2)</b>	<b>0.125(32)</b>	<b>63.63</b>
	MIC/4	4(1)	8(0.5)	4(1)	<b>1(4)</b>	16(0.25)	<b>2(2)</b>	4(1)	8(0.5)	4(1)	4(1)	<b>0.5(8)</b>	<b>27.27</b>
OFL	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>54.54</b>
	MIC/4	2(1)	2(1)	4(0.5)	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	4(0.5)	4(0.5)	2(1)	2(1)	$\geq 8$ (nd)	<b>18.18</b>
CHL	0	256	256	256	256	256	256	256	256	256	256	256	
	MIC/2	<b>128(2)</b>	<b>64(4)</b>	<b>128(2)</b>	<b>64(4)</b>	256(1)	<b>128(2)</b>	<b>128(2)</b>	<b>128(2)</b>	<b>64(4)</b>	<b>128(2)</b>	<b>128(2)</b>	<b>90.90</b>
	MIC/4	256(1)	256(1)	256(1)	<b>128(2)</b>	512(0.5)	256(1)	256(1)	256(1)	<b>128(2)</b>	256(1)	<b>128(2)</b>	<b>27.27</b>
CIP	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>63.63</b>
	MIC/4	4(0.5)	2(1)	2(1)	<b>1(2)</b>	4(0.5)	2(1)	4(0.5)	<b>1(2)</b>	2(1)	2(1)	$\geq 8$ (nd)	<b>18.18</b>
FLU	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	81.81
	MIC/4	<b>1(2)</b>	2(1)	2(1)	<b>1(2)</b>	2(1)	2(1)	2(1)	4(0.5)	2(1)	4(0.5)	2(1)	18.18
CLO	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	2(1)	2(1)	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	72.72
	MIC/4	<b>1(2)</b>	4(0.5)	4(0.5)	<b>1(2)</b>	4(0.5)	2(1)	2(1)	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	36.36
TET	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	4(0.5)	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	81.81
	MIC/4	<b>1(2)</b>	4(0.5)	2(1)	<b>1(2)</b>	8(0.25)	<b>1(2)</b>	2(1)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	36.36
KAN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	2(1)	2(1)	<b>1(2)</b>	2(1)	<b>0.25(8)</b>	63.63
	MIC/4	2(1)	2(1)	2(1)	<b>1(2)</b>	4(0.5)	2(1)	4(0.5)	4(0.5)	2(1)	4(0.5)	<b>0.5(4)</b>	18.18
DOX	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	2(1)	2(1)	<b>0.25(8)</b>	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	72.72
	MIC/4	2(1)	4(0.5)	4(0.5)	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	2(1)	<b>2(1)</b>	2(1)	2(1)	<b>1(2)</b>	27.27
AZI	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.25(8)</b>	90.90
	MIC/4	2(1)	4(0.5)	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	2(1)	2(1)	2(1)	<b>0.5(4)</b>	27.27

MIC : Minimum Inhibitory Concentration ; ERY : Erythromycin; GEN: Gentamycin; THI: Thiamphenicol; OFL: Ofloxacin; CHL: Chloramphenicol; CIP: Ciprofloxacin; FLU: Flucloxacillin; CLO: Cloxacillin; TET: Tetracycline; KAN: Kanamycin; DOX: Doxycycline; AZI: Azithromycin; ( ) : IAF ( Improvement activity factor).

**Table 7.** MIC values ( $\mu\text{g/mL}$ ) of antibiotics in the presence of *Ternstroemia cameroonensis* fruits extract and IAF values

Antibiotics	Concentration of extract	Bacterial strains and isolates											Modulation effect of antibiotic (%)
		<i>E. coli</i>		<i>E. aerogenes</i>		<i>P. stuartii</i>		<i>K. pneumoniae</i>		<i>S. aureus</i>		<i>P. aeruginosa</i>	
		AG100 Atet	ATCC 10536	EA27	ATCC 13048	NEA16	ATCC 29916	KP55	KP63	ATCC 25923	MRSA9	PA124	
ERY	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	8(0.25)	2(1)	4(0.5)	2(1)	2(1)	2(1)	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>09.09</b>
	MIC/4	4(0.5)	4(0.5)	$\geq 8$ (nd)	4(0.5)	8(0.25)	4(0.5)	4(0.5)	4(0.5)	2(1)	4(0.5)	$\geq 8$ (nd)	<b>00</b>
GEN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	2(1)	4(0.5)	2(1)	4(0.5)	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>36.36</b>
	MIC/4	2(1)	4(0.5)	8(0.25)	4(0.5)	8(0.25)	4(0.5)	2(1)	4(0.5)	2(1)	4(0.5)	$\geq 8$ (nd)	<b>00</b>
THI	0	4	4	4	4	4	4	4	4	4	4	4	
	MIC/2	<b>2(2)</b>	16(0.25)	8(0.5)	<b>2(2)</b>	4(1)	<b>1(4)</b>	<b>2(2)</b>	4(1)	<b>2(2)</b>	<b>2(2)</b>	$\geq 16$ (nd)	<b>54.54</b>
	MIC/4	4(1)	$\geq 16$ (nd)	16(0.25)	4(1)	8(0.5)	<b>2(2)</b>	4(1)	8(0.5)	4(1)	4(1)	$\geq 16$ (nd)	<b>09.09</b>
OFL	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>36.36</b>
	MIC/4	4(0.5)	4(0.5)	4(0.5)	2(1)	4(0.5)	2(1)	4(0.5)	4(0.5)	2(1)	2(1)	$\geq 8$ (nd)	<b>00</b>
CHL	0	256	256	256	256	256	256	256	256	256	256	256	
	MIC/2	256(1)	256(1)	512(0.5)	<b>128(2)</b>	256(1)	<b>128(2)</b>	256(1)	<b>128(2)</b>	<b>64(4)</b>	<b>128(2)</b>	<b>128(2)</b>	<b>54.54</b>
	MIC/4	512(0.5)	512(0.5)	1024(0.25)	256(1)	512(0.5)	256(1)	512(0.5)	256(1)	<b>128(2)</b>	256(1)	<b>128(2)</b>	<b>18.18</b>
CIP	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	<b>1(2)</b>	8(0.25)	2(1)	2(1)	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>1(2)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>45.45</b>
	MIC/4	4(0.5)	2(1)	$\geq 8$ (nd)	4(0.5)	4(0.5)	2(1)	4(0.5)	<b>1(2)</b>	2(1)	2(1)	$\geq 8$ (nd)	<b>09.09</b>
FLU	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	4(0.5)	4(0.5)	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>54.54</b>
	MIC/4	2(1)	8(0.25)	8(0.25)	2(1)	4(0.5)	2(1)	4(0.5)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	<b>09.09</b>
CLO	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	4(0.5)	4(0.5)	2(1)	4(0.5)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	<b>63.63</b>
	MIC/4	2(1)	8(0.25)	8(0.25)	4(0.5)	8(0.25)	2(1)	2(1)	2(1)	2(1)	2(1)	<b>1(2)</b>	<b>09.09</b>
TET	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	4(0.5)	8(0.25)	<b>1(2)</b>	4(0.5)	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>0.25(8)</b>	<b>54.54</b>
	MIC/4	2(1)	8(0.25)	$\geq 8$ (nd)	2(1)	8(0.25)	4(0.5)	2(1)	4(0.5)	2(1)	2(1)	<b>0.5(4)</b>	<b>09.09</b>
KAN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>63.63</b>
	MIC/4	2(1)	4(0.5)	4(0.5)	2(1)	4(0.5)	2(1)	2(1)	4(0.5)	2(1)	4(0.5)	<b>1(2)</b>	<b>09.09</b>
DOX	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	2(1)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	<b>45.45</b>
	MIC/4	2(1)	4(0.5)	8(0.25)	4(0.5)	4(0.5)	2(1)	4(0.5)	2(1)	2(1)	4(0.5)	2(1)	<b>00</b>
AZI	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	4(0.5)	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>45.45</b>
	MIC/4	4(0.5)	4(0.5)	8(0.25)	2(1)	4(0.5)	2(1)	2(1)	4(0.5)	2(1)	4(0.5)	2(1)	<b>00</b>

MIC : Minimum Inhibitory Concentration ; ERY : Erythromycin; GEN: Gentamycin; THI: Thiamphenicol; OFL: Ofloxacin; CHL: Chloramphenicol; CIP: Ciprofloxacin; FLU: Flucloxacillin; CLO: Cloxacillin; TET: Tetracycline; KAN: Kanamycin; DOX: Doxycycline; AZI: Azithromycin; ( ) : IAF ( Improvement activity factor).

**Table 8.** MIC values ( $\mu\text{g/mL}$ ) of antibiotics in the presence of *Ternstroemia cameroonensis* leaves extract and IAF values

Antibiotics	Concentration of extract	Bacterial strains and isolates											Modulation effect of antibiotic (%)
		<i>E. coli</i>		<i>E. aerogenes</i>		<i>P. stuartii</i>		<i>K. pneumoniae</i>		<i>S. aureus</i>		<i>P. aeruginosa</i>	
		AG100 Atet	ATCC 10536	EA27	ATCC 13048	NEA16	ATCC 29916	KP55	KP63	ATCC 25923	MRSA9	PA124	
ERY	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	2(1)	4(0.5)	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	4(0.5)	2(1)	2(1)	$\geq 8$ (nd)	<b>18.18</b>
	MIC/4	8(0.25)	4(0.5)	4(0.5)	4(0.5)	4(0.5)	2(1)	<b>1(2)</b>	4(0.5)	4(0.5)	2(1)	$\geq 8$ (nd)	<b>09.09</b>
GEN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>1(2)</b>	<b>1(2)</b>	4(0.5)	2(1)	4(0.5)	8(0.25)	8(0.25)	<b>0.5(4)</b>	<b>0.125(16)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>54.54</b>
	MIC/4	2(1)	2(1)	8(0.25)	4(0.5)	8(0.25)	8(0.25)	8(0.25)	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	$\geq 8$ (nd)	<b>18.18</b>
THI	0	4	4	4	4	4	4	4	4	4	4	4	
	MIC/2	<b>0.5(8)</b>	4(1)	4(1)	<b>2(2)</b>	<b>2(2)</b>	4(1)	<b>1(4)</b>	<b>1(4)</b>	<b>1(4)</b>	<b>2(2)</b>	<b>0.5(8)</b>	<b>72.72</b>
	MIC/4	<b>2(2)</b>	8(0.5)	8(0.5)	8(0.5)	4(1)	4(1)	16(0.25)	<b>2(2)</b>	2(0.5)	4(1)	<b>0.5(8)</b>	<b>27.27</b>
OFL	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	<b>1(2)</b>	4(0.5)	<b>0.5(4)</b>	<b>1(2)</b>	4(0.5)	<b>0.125(16)</b>	$\geq 8$ (nd)	<b>0.25(8)</b>	<b>1(2)</b>	2(1)	<b>54.54</b>
	MIC/4	4(0.5)	2(1)	8(0.25)	<b>1(2)</b>	4(0.5)	4(0.5)	<b>0.5(4)</b>	$\geq 8$ (nd)	<b>0.25(8)</b>	<b>1(2)</b>	$\geq 8$ (nd)	<b>36.36</b>
CHL	0	256	256	256	256	256	256	256	256	256	256	256	
	MIC/2	<b>128(2)</b>	<b>64(4)</b>	<b>128(2)</b>	<b>16(16)</b>	256(1)	<b>128(2)</b>	<b>128(2)</b>	512(0.5)	<b>64(4)</b>	<b>64(4)</b>	$\geq 1024$ (nd)	<b>72.72</b>
	MIC/4	256(1)	256(1)	256(1)	<b>32(8)</b>	512(0.5)	256(1)	256(1)	1024(0.25)	<b>128(2)</b>	256(1)	$\geq 1024$ (nd)	<b>18.18</b>
CIP	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.25(8)</b>	<b>1(2)</b>	4(0.5)	<b>0.25(8)</b>	4(0.5)	2(1)	<b>1(2)</b>	<b>0.15(16)</b>	<b>0.125(16)</b>	2(1)	<b>1(2)</b>	<b>63.63</b>
	MIC/4	<b>0.5(4)</b>	$\geq 8$ (nd)	8(0.25)	<b>1(2)</b>	8(0.25)	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	2(1)	2(1)	<b>45.45</b>
FLU	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	<b>1(2)</b>	2(1)	2(1)	4(0.5)	<b>0.5(4)</b>	<b>0.5(4)</b>	2(1)	<b>0.25(8)</b>	<b>0.25(8)</b>	<b>45.45</b>
	MIC/4	4(0.5)	4(0.5)	4(0.5)	4(0.5)	4(0.5)	8(0.25)	<b>1(2)</b>	<b>1(2)</b>	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	<b>36.36</b>
CLO	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	4(0.5)	2(1)	<b>1(2)</b>	<b>0.5(4)</b>	2(1)	8(0.25)	<b>0.5(4)</b>	<b>0.25(8)</b>	2(1)	2(1)	<b>0.25(8)</b>	<b>45.45</b>
	MIC/4	4(0.5)	4(0.5)	4(0.5)	8(0.25)	4(0.5)	8(0.25)	<b>1(2)</b>	2(1)	<b>1(2)</b>	8(0.25)	<b>1(2)</b>	<b>27.27</b>
TET	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	4(0.5)	<b>1(2)</b>	<b>1(2)</b>	<b>0.5(4)</b>	$\geq 8$ (nd)	<b>1(2)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.25(8)</b>	<b>63.63</b>
	MIC/4	8(0.25)	4(0.5)	8(0.25)	4(0.5)	4(0.5)	<b>1(2)</b>	$\geq 8$ (nd)	2(1)	8(0.25)	2(1)	<b>0.5(4)</b>	<b>18.18</b>
KAN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	4(0.5)	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>1(2)</b>	<b>0.25(8)</b>	2(1)	<b>0.5(4)</b>	<b>63.63</b>
	MIC/4	<b>0.5(4)</b>	2(1)	4(0.5)	2(1)	4(0.5)	2(1)	<b>1(4)</b>	4(0.5)	<b>1(2)</b>	8(0.25)	<b>1(2)</b>	<b>36.36</b>
DOX	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	8(0.25)	<b>0.5(4)</b>	<b>0.5(4)</b>	<b>63.63</b>
	MIC/4	8(0.25)	4(0.5)	4(0.5)	2(1)	2(1)	2(1)	2(1)	2(1)	8(0.25)	<b>1(2)</b>	2(1)	<b>09.09</b>
AZI	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.25(8)</b>	2(1)	2(1)	2(1)	2(1)	4(0.5)	4(0.5)	<b>1(2)</b>	<b>0.125(16)</b>	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>45.45</b>
	MIC/4	2(1)	4(0.5)	4(0.5)	4(0.5)	4(0.5)	8(0.25)	8(0.25)	2(1)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>27.27</b>

MIC : Minimum Inhibitory Concentration ; ERY : Erythromycin; GEN: Gentamycin; THI: Thiamphenicol; OFL: Ofloxacin; CHL: Chloramphenicol; CIP: Ciprofloxacin; FLU: Flucloxacillin; CLO: Cloxacillin; TET: Tetracycline; KAN: Kanamycin; DOX: Doxycycline; AZI: Azithromycin; ( ) : IAF ( Improvement activity factor).

**Table 9.** MIC values ( $\mu\text{g/mL}$ ) of antibiotics in the presence of *Ternstroemia cameroonensis* bark extract and IAF values

Antibiotics	Concentration of extract	Bacterial strains and isolates										Modulation effect of antibiotic (%)	
		<i>E. coli</i>		<i>E. aerogenes</i>		<i>P. stuartii</i>		<i>K. pneumoniae</i>		<i>S. aureus</i>			<i>P. aeruginosa</i>
		AG100 Atet	ATCC 10536	EA27	ATCC 13048	NEA16	ATCC 29916	KP55	KP63	ATCC 25923	MRSA9		PA124
ERY	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.25(8)</b>	2(1)	4(0.5)	<b>1(2)</b>	2(1)	<b>0.5(4)</b>	4(0.5)	<b>0.25(8)</b>	<b>0.5(4)</b>	2(1)	<b>1(2)</b>	<b>54.54</b>
	MIC/4	<b>1(2)</b>	4(0.5)	8(0.25)	4(0.5)	4(0.5)	2(1)	8(0.25)	<b>0.5(4)</b>	2(1)	4(0.5)	<b>1(2)</b>	<b>27.27</b>
GEN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	4(0.5)	4(0.5)	2(1)	<b>0.5(4)</b>	8(0.25)	<b>0.5(4)</b>	$\geq 8$ (nd)	2(1)	<b>1(2)</b>	<b>45.45</b>
	MIC/4	2(1)	2(1)	8(0.25)	$\geq 8$ (nd)	4(0.5)	<b>1(2)</b>	8(0.25)	4(0.5)	$\geq 8$ (nd)	8(0.25)	<b>1(2)</b>	<b>18.18</b>
THI	0	4	4	4	4	4	4	4	4	4	4	4	
	MIC/2	<b>2(2)</b>	<b>1(4)</b>	8(0.5)	<b>2(2)</b>	8(0.5)	<b>1(4)</b>	<b>2(2)</b>	<b>1(4)</b>	8(0.5)	4(1)	<b>2(2)</b>	<b>63.63</b>
	MIC/4	4(1)	<b>2(2)</b>	16(0.25)	4(1)	16(0.25)	4(1)	<b>1(4)</b>	4(1)	8(0.5)	16(0.25)	<b>2(2)</b>	<b>27.27</b>
OFL	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	<b>1(2)</b>	4(0.5)	4(0.5)	2(1)	<b>0.5(4)</b>	<b>0.125(16)</b>	<b>0.125(16)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	$\geq 8$ (nd)	<b>54.54</b>
	MIC/4	4(0.5)	2(1)	8(0.25)	8(0.25)	4(0.5)	2(1)	<b>0.25(8)</b>	8(0.25)	<b>0.5(4)</b>	4(0.5)	$\geq 8$ (nd)	<b>18.18</b>
CHL	0	256	256	256	256	256	256	256	256	256	256	256	
	MIC/2	<b>128(2)</b>	<b>64(4)</b>	256(1)	<b>32(8)</b>	256(1)	<b>64(4)</b>	<b>16(16)</b>	<b>32(16)</b>	256(1)	<b>64(4)</b>	<b>64(4)</b>	<b>72.72</b>
	MIC/4	256(1)	<b>128(2)</b>	512(0.5)	<b>64(4)</b>	512(0.5)	256(1)	<b>32(8)</b>	<b>128(2)</b>	256(1)	<b>128(2)</b>	<b>64(4)</b>	<b>54.54</b>
CIP	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	4(0.5)	<b>0.25(8)</b>	2(1)	<b>0.5(4)</b>	<b>0.25(8)</b>	<b>0.5(4)</b>	<b>1(2)</b>	2(1)	$\geq 8$ (nd)	<b>63.63</b>
	MIC/4	<b>1(2)</b>	2(1)	8(0.25)	<b>0.5(4)</b>	4(0.5)	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	<b>1(2)</b>	4(0.5)	$\geq 8$ (nd)	<b>54.54</b>
FLU	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	2(1)	<b>0.5(4)</b>	8(0.25)	<b>1(2)</b>	$\geq 8$ (nd)	<b>1(2)</b>	<b>1(2)</b>	<b>63.63</b>
	MIC/4	<b>1(2)</b>	<b>1(2)</b>	4(0.5)	2(1)	4(0.5)	<b>1(2)</b>	8(0.25)	2(1)	$\geq 8$ (nd)	4(0.5)	2(1)	<b>27.27</b>
CLO	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	4(0.5)	2(1)	4(0.5)	<b>0.5(8)</b>	2(1)	<b>0.5(4)</b>	<b>0.5(4)</b>	4(0.5)	2(1)	<b>0.25(8)</b>	<b>0.5(4)</b>	<b>45.45</b>
	MIC/4	4(0.5)	4(0.5)	8(0.25)	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	2(1)	8(0.25)	4(1)	2(1)	<b>1(2)</b>	<b>27.27</b>
TET	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	8(0.25)	<b>1(2)</b>	4(0.5)	2(1)	2(1)	<b>0.25(8)</b>	<b>0.5(4)</b>	<b>0.5(4)</b>	4(0.5)	2(1)	<b>1(2)</b>	<b>45.45</b>
	MIC/4	8(0.25)	4(0.5)	8(0.25)	8(0.25)	4(0.5)	<b>1(2)</b>	<b>1(2)</b>	2(1)	8(0.25)	4(0.5)	2(1)	<b>18.18</b>
KAN	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	<b>1(2)</b>	2(1)	2(1)	2(1)	<b>1(2)</b>	4(0.5)	2(1)	4(0.5)	4(0.5)	<b>0.5(4)</b>	<b>27.27</b>
	MIC/4	8(0.25)	2(1)	4(0.5)	4(0.5)	4(0.5)	2(1)	4(0.5)	4(0.5)	8(0.25)	4(0.5)	4(0.5)	<b>00</b>
DOX	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	2(1)	2(1)	4(0.5)	<b>0.25(8)</b>	2(1)	<b>0.5(4)</b>	4(0.5)	<b>0.25(8)</b>	8(0.25)	2(1)	<b>0.5(4)</b>	<b>36.36</b>
	MIC/4	4(0.5)	4(0.5)	8(0.25)	<b>1(2)</b>	4(0.5)	<b>1(2)</b>	4(0.5)	<b>0.5(4)</b>	8(0.25)	2(1)	<b>1(2)</b>	<b>36.36</b>
AZI	0	2	2	2	2	2	2	2	2	2	2	2	
	MIC/2	<b>0.5(4)</b>	<b>1(2)</b>	4(0.5)	2(1)	2(1)	2(1)	<b>1(2)</b>	<b>0.125(16)</b>	2(1)	<b>1(2)</b>	<b>0.25(8)</b>	<b>54.54</b>
	MIC/4	2(1)	2(1)	8(0.25)	4(0.5)	4(0.5)	2(1)	2(1)	<b>1(2)</b>	4(0.5)	2(1)	<b>0.5(4)</b>	<b>18.18</b>

MIC : Minimum Inhibitory Concentration ; ERY : Erythromycin; GEN: Gentamycin; THI: Thiamphenicol; OFL: Ofloxacin; CHL: Chloramphenicol; CIP: Ciprofloxacin; FLU: Flucloxacillin; CLO: Cloxacillin; TET: Tetracycline; KAN: Kanamycin; DOX: Doxycycline; AZI: Azithromycin; ( ) : IAF ( Improvement activity factor).

## Conclusion

The present study provides additional information on the possible use of Cameroonian medicinal plants in the control of bacterial infections, including resistant phenotypes. The results obtained in this work indicate that extracts of *Ternstroemia cameroonensis* bark, *Neoboutonia glabrescens*, and *Ficus exasperata* leaves, *Desmodium uncinatum*, and *Erigeron floribundus* whole plants can be used alone or in combination with antibiotics against bacterial infections involving multidrug-resistant bacteria.

## Additional file

S1. Bacterial strains and features; S2. Preliminary evaluation of antibiotic-resistance modulatory activity of selected samples at sub-inhibitory concentrations against *Pseudomonas aeruginosa* PA124. Available at <https://www.investchempharma.com/imcp62-supplementary-file/>

## Abbreviations

ATB: Antibiotic; ATCC: American Type Culture Collection; AZI : Azithromycin; CFU: Colony Forming Unit; CHL: Chloramphenicol; CIP: Ciprofloxacin; CLO: Cloxacillin; DMSO: Dimethyl sulfoxide; DOX: Doxycycline; *E. aerogenes*: *Enterobacter aerogenes*; *E. coli*: *Escherichia coli*; EPI: Efflux Pumps Inhibitors; ERY: Erythromycin; FLU : Flucloxacillin; GEN : Gentamycin; IAF: Improvement activity factor; INT: p-iodonitrotetrazolium chloride  $\geq 97\%$  (INT, Sigma-Aldrich); *K. pneumoniae*: *Klebsiella pneumoniae*; KAN: Kanamycin; MBC: Minimal Bactericidal Concentration; MDR: Multidrug resistant; MHB: Mueller Hinton Broth; MIC: Minimal Inhibitory Concentration; OFL : Ofloxacin; *P. aeruginosa*: *Pseudomonas aeruginosa*; *P. stuartii*: *Providencia stuartii*; *P. aureus*: *Staphylococcus aureus*; TET: Tetracycline; THI: Thiamphenicol, WHO: World Health Organization.

## Authors' Contribution

ACK and CFT carried out the study and designed the experiments; CFT wrote the manuscript; ATM VK supervised the work; VK provided the bacterial strains and facilities for antibacterial assays; all authors read and approved the final manuscript.

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## Conflict of interest

The authors declare no conflict of interest

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