



Elucidation of the antibacterial and antioxidant properties of aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii* Gilg (*Loganiaceae*) against three enterobacteria responsible for gastroenteritis

Landry KENGNE GOUNMADJE¹, Steve Valdi DJOVA², Steve Henri VOUNDI OLUGU³,
Muriel Maella LEBIKA BANGROUP⁴, Dimitri NGONGANG TCHAMI⁵, Maximilienne
Ascension NYEGUE^{6*}

¹Yaoundé I University, Science Faculty, Department of Biochemistry, Yaoundé, Cameroon

²Bamenda University, Science Faculty, Department of Biochemistry, Bamenda, Cameroon

³Douala University, University Institute of Technology, Douala, Cameroon

^{4,6}Yaoundé I University, Science Faculty, Department of Microbiology, Yaoundé, Cameroon

*landryken12@gmail.com, ¹landryken12@yahoo.fr, ²djova.stevevaldi@yahoo.fr, ³voundisteve@yahoo.fr,

⁴murielarkange@yahoo.fr, ⁵dimingongang@yahoo.fr

Anthocleista schweinfurthii Gilg (*Loganiaceae*) bitkisinin sulu ve hidroetanolik özütlerinin gastroenterite neden olan üç enterobakteriye karşı antibakteriyel ve antioksidan özelliklerinin aydınlatılması

Received : 02.06.2026
Accepted : 22.08.2026
Online : 18.09.2026

Abstract: This study aimed to evaluate the antibacterial and antioxidant properties of aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii* on three enterobacteria responsible for gastroenteritis. Aqueous and hydroethanolic extracts were prepared from the leaves, stem bark, and roots by maceration. The well diffusion and microdilution methods were used to assess the antibacterial activity of the extracts against three reference strains responsible for gastroenteritis, namely *Escherichia coli* (ATCC 25922), *Shigella sonnei* (CMCC51630), and *Salmonella enterica* serovar Typhi (200836550). The antioxidant activity of the extracts was evaluated using DPPH, ABTS, and FRAP methods. Total polyphenols, primary and secondary antioxidants were assessed using the Folin-Ciocalteu assay. The aqueous and hydroethanolic root extracts demonstrated antibacterial activity against *Shigella sonnei* (CMCC51630) and *Salmonella typhi* (200836550), respectively, with inhibition diameters ranging from 17 ± 1.41 to 21 ± 1.41 mm. The MICs of the extracts ranged from 64 to 512 $\mu\text{g/mL}$. The aqueous root extracts were the most potent, with the lowest MIC of 64 $\mu\text{g/mL}$. All extracts were bactericidal against *Salmonella enterica* serovar Typhi (200836550), while the aqueous root extract was bacteriostatic against *Shigella sonnei* (CMCC51630). The aqueous root extract showed the strongest free radical scavenging activity (3.638 ± 0.001), the highest reducing power (427.57 mg EAA/g extract), and the greatest secondary antioxidant content (213.8 mg EAA/g extract). The hydroethanolic root extract was rich in total polyphenols, with a content of 441.49 mg EAA/g DW. *Anthocleista schweinfurthii* extracts exhibit antibacterial and antioxidant properties, which are essential for treating gastroenteritis and oxidative stress.

Key words: Gastroenteritis, *Anthocleista schweinfurthii*, antibacterial effect, antioxidant activity, phytochemical screening

Özet: Bu çalışma, *Anthocleista schweinfurthii*'nin sulu ve hidroetanolik özütlerinin gastroenterite neden olan üç enterobakteri üzerindeki antibakteriyel ve antioksidan özelliklerini değerlendirmeyi amaçlamıştır. Sulu ve hidroetanolik özütler, yapraklar, gövde kabuğu ve köklerden maserasyon yöntemiyle hazırlanmıştır. Özütlerin antibakteriyel aktivitesi, gastroenterite neden olan üç referans suşuna (*Escherichia coli* (ATCC 25922), *Shigella sonnei* (CMCC51630) ve *Salmonella enterica* serovar Typhi (200836550)) karşı kuyu difüzyon ve mikrodilüsyon yöntemleri kullanılarak değerlendirilmiştir. Özütlerin antioksidan aktivitesi DPPH, ABTS ve FRAP yöntemleri kullanılarak değerlendirilmiştir. Toplam polifenoller, birincil ve ikincil antioksidanlar Folin-Ciocalteu testi kullanılarak değerlendirilmiştir. Sulu ve hidroetanolik kök özütleri, *Shigella sonnei*'ye karşı antibakteriyel aktivite göstermiştir. (CMCC51630) ve *Salmonella typhi* (200836550)'ye karşı sırasıyla $17 \pm 1,41$ ila $21 \pm 1,41$ mm arasında değişen inhibisyon çaplarına sahip olan ekstraktların MIC değerleri 64 ila 512 $\mu\text{g/mL}$ arasında değişmiştir. Sulu kök ekstraktları en güçlü olanlardı ve en düşük MIC değeri 64 $\mu\text{g/mL}$ idi. Tüm ekstraktlar *Salmonella enterica* serovar Typhi (200836550)'ye karşı bakterisidal etki gösterirken, sulu kök ekstraktı *Shigella sonnei* (CMCC51630)'a karşı bakteriyostatik etki göstermiştir. Sulu kök ekstraktı en güçlü serbest radikal temizleme aktivitesini ($3,638 \pm 0,001$), en yüksek indirgeyici gücü (427,57 mg EAA/g ekstrakt) ve en yüksek ikincil antioksidan içeriğini (213,8 mg EAA/g ekstrakt) göstermiştir. Hidroetanolik kök ekstresi, 441,49 mg EAA/g DW içeriğiyle toplam polifenol bakımından zengindir. *Anthocleista schweinfurthii* ekstreleri, gastroenterit ve oksidatif stresi tedavi etmek için gerekli olan antibakteriyel ve antioksidan özellikler sergiler.

Anahtar Kelimeler: Gastroenterit, *Anthocleista schweinfurthii*, antibakteriyel etki, antioksidan aktivite, fitokimyasal tarama

Citation: Kengne Gounmadje L, Djova SV, Voundi Olugu SH, Lebika Bangoup HM, Ngongang Tchami D, Nyegue MA (2026). Elucidation of the antibacterial and antioxidant properties of aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii* Gilg (*Loganiaceae*) against three enterobacteria responsible for gastroenteritis. Anatolian Journal of Botany 10(2): 194-203.

1. Introduction

Infectious diseases result from the invasion of a host by microscopic pathogens (bacteria, viruses, fungi, or

protozoa), leading to conditions such as gastroenteritis, pneumonia, and malaria. Gastroenteritis is the inflammation of the digestive tract affecting the stomach,

small intestine, and colon (Dongmo et al., 2015). The most common symptoms are diarrhea, vomiting, and abdominal pain. Many pathogens can cause gastroenteritis, including members of the Enterobacteriaceae. Contamination can also be orofecal. Those most affected are newborns and young children, the elderly, and immunocompromised patients. Gastroenteritis causes about 800,000 deaths each year, including 500,000 children under five, making up over 60% of these deaths. Besides its immediate danger, the condition is linked to the development of gastric ulcers and colorectal cancers. (Okou et al., 2018). It is the second major cause of death in children under 5 in Cameroon after acute respiratory infections.

During bacterial infection, large amounts of free radicals, such as reactive oxygen species (ROS), are produced and accumulate in the digestive tract, leading to oxidative stress. These free radicals may cause damage to various cellular components, including lipids, DNA, carbohydrates, and proteins. This damage can result in the formation of molecular aggregates, which are an initial step in the development of metabolic and degenerative diseases such as cardiovascular disease, diabetes, premature cellular aging, inflammation, Alzheimer's disease, rheumatism, and some types of cancer (Beaudeux and Durand, 2011).

The growing number of bacterial infections has spurred the development of new antibiotics to fight these pathogens. However, bacteria quickly developed resistance to these antibiotics due to their overuse and inappropriate use, poor infection prevention and control practices in healthcare settings and on farms, and side effects such as allergies. Due to the complex resistance problem, it is necessary to explore several avenues to address it, such as studies of traditional pharmacopeia that promote the use of local medicinal plants (Onzo et al., 2014).

In developing countries, 80% of people rely on medicinal plants to treat various diseases. Fortunately, Africa accounts for 90% of traditional herbal medicines, which generally have fewer side effects (WHO, 2002). One such plant is *Anthocleista schweinfurthii*, a member of the Loganiaceae family found in tropical Africa and Madagascar. It is known locally as *bopolopolo* in the Douala language or *Abanga'a* in the Tumu Fang language (Cameroon, Gabon, and Equatorial Guinea). A decoction made from its bark, roots, and leaves is used to treat malaria, injuries, inflammatory conditions, and pain (Christophe et al., 2015). Previous investigations into *Anthocleista schweinfurthii* Gilg have revealed a rich phytochemical profile alongside promising biological properties. Chemical screening of various plant parts (leaves, stem bark, roots, and fruits) has established the presence of bioactive secondary metabolites, including polyphenols, alkaloids, terpenes, steroids, and specific xanthone derivatives such as swertiaperenin and decussatin (Mubindikila et al., 2014; Nkouam et al., 2022). Pharmacological studies demonstrate significant antibacterial efficacy, with stem bark and leaf fractions exhibiting potent inhibitory activity against both Gram-positive (e.g., *Staphylococcus aureus*, *Bacillus cereus*) and Gram-negative pathogens (e.g., *Escherichia coli*) (Mubindikila et al., 2014; Nkouam et al., 2022). In addition, crude methanolic extracts and isolated xanthone constituents exhibit strong antioxidant and radical-scavenging capabilities ($IC_{50} < 10 \mu\text{g/mL}$ in DPPH assays) (Mubindikila et al., 2014; Nkouam et al., 2022).

Furthermore, *A. schweinfurthii* extracts have demonstrated notable cytotoxic and antiproliferative effects against human cancer cell lines, including multidrug-resistant phenotypes. (Kute et al., 2016; Djova et al., 2018). In terms of safety, toxicity assessments of the stem bark aqueous extract revealed no lethal or adverse behavioral, hematological, biochemical, or histological effects in acute (single dose of 2000 mg/kg, $LD_{50} > 2000 \text{ mg/kg}$) and subacute (28-day repeated oral administration up to 1000 mg/kg) animal models (Mezui et al., 2015).

Therefore, this study aimed to evaluate the antibacterial and antioxidant activities of aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii* on three enterobacteria responsible for gastroenteritis.

2. Materials and Method

2.1. Plant material

Anthocleista schweinfurthii was collected in Loum, Littoral region, Cameroon, in December 2020. Botanical identification and authentication were conducted at the National Herbarium of Cameroon in Yaoundé, where the specimen was compared with the specimen identified as 52349HNC.

2.2. Microbiological material

The reference bacterial strains *Escherichia coli* (ATCC25922), *Shigella sonnei*. (CMCC51630), and *Salmonella enterica* serovar Typhi (200836550) were obtained from the Center for the Study and Control of Communicable Diseases (CSCCD) in Cameroon, specifically at the Faculty of Medicine and Biomedical Sciences at the University of Yaoundé 1. These strains were stored at 4 °C on Mueller-Hinton agar in Petri dishes and then activated on agar medium. Mueller-Hinton agar (MHA) culture medium was also used to renew bacterial strains and to perform susceptibility testing against extracts and the reference antibiotic.

2.3. Extraction Procedure

Extracts were obtained as previously described by Djova et al (2018). The leaves, bark, and roots were cut into small pieces with a knife and air-dried on clean tarps at room temperature in the shade for 14 days. They were then ground separately into powders using an electric grinder. These powders were weighed (leaves: 533 g, stem bark: 1176.7 g, roots: 338.3 g) and used to prepare the aqueous and hydroethanolic extracts by maceration. The extracts were prepared using two solvents: water and a 70% ethanol/water (8:2, v/v) mixture. Each powder was divided in half and mixed with the extraction solvent at room temperature for the recommended time. One part of each powder was macerated in 1000 mL of distilled water for 48 hours (aqueous extraction), while the other part was macerated in 1000 mL of a mixture of 350 mL 95% ethanol and 650 mL water for 48 hours (hydroethanolic extraction). The maceration was performed twice. Afterward, the homogenates were filtered twice through cotton wool and once through Whatman No. 1 paper. The filtrates for aqueous extracts were dried by lyophilization (72 hours), and the hydroethanolic extracts were dried via rotary evaporation at 80 °C. The extracts were weighed, stored in sterile, labeled screw-cap tubes at 4 °C, and their yields were recorded (Prakash et al., 2009).

2.4. Phytochemical screening

A qualitative phytochemical screening was conducted using standard methods to detect various classes of compounds in the extracts.

Phenol and polyphenol test: Three milliliters of a freshly prepared 5% ferric chloride solution were added to 0.5 g of extract dissolved in 2 mL of distilled water, and the mixture was left for 5 minutes. After homogenization, a few drops of a potassium ferricyanide solution were added. The observation of a green (phenol) or blue (polyphenol) precipitate indicates a positive reaction (Harborne, 1998). Effects of aqueous and hydroethanolic extracts of two medicinal plants compared to common antibiotics on urogenital mycoplasmas.

Tannin test: 500 mg of extract is added to 5 ml of distilled water. The mixture is heated in a water bath for 5 minutes, then filtered after cooling. Next, a few drops of 3% ferric chloride are added to the filtrate. The presence of tannins is indicated by the appearance of a dark blue color for gallic tannins and a blackish green color for catechin tannins (Harborne, 1998).

Saponin test: 500 mg of extract was dissolved in 5 ml of distilled water. After homogenization, the mixture was heated to a boil for 5 minutes. The presence of saponins was indicated by the appearance of resistant foam after 1 minute (Harborne, 1998).

Flavonoid test: 500 mg of extract was dissolved in 5 ml of distilled water, then 2.5 ml of 10% NaOH was added to 1 ml of the filtrate. The appearance of a yellow precipitate indicated the presence of flavonoids (Sofowara, 1993).

Alkaloid test: 500 mg of extract was heated in 10 ml of 1% sulphuric acid for 2 to 3 minutes, then filtered. A few drops of Mayer's reagent were added to 1 ml of the filtrate. The formation of a white precipitate or turbidity indicated the presence of alkaloids (Harborne, 1998).

Testing for triterpenes and steroids: 500 mg of extract was dissolved in 3 ml of chloroform. A few drops of acetic anhydride and concentrated sulphuric acid (H_2SO_4) were added to this solution. The presence of triterpenes is indicated by a purplish-red (purple) color change, while a greenish-blue color is characteristic of steroids; the formation of two phases after the addition of H_2SO_4 is characteristic of triterpenes and steroids (Harborne, 1998).

Anthocyanin test: 100 mg of extract was dissolved in 5 ml of a 1% sulphuric acid solution. The appearance of orange indicated the presence of anthocyanins (Harborne, 1998).

Anthraquinone test: 50 mg of extract was diluted in 4 ml of a chloroform-petroleum ether (v/v) mixture, homogenized, and then filtered. 1 ml of filtrate was added to an equal volume of 10% NaOH. The development of a red coloration enabled the anthraquinones to be characterized (Evans, 2000).

2.5. Evaluation of the antibacterial activity

2.5.1. Agar-well diffusion method (Sensitivity assay)

This assay was performed using the agar well diffusion method, with inhibition zone diameters measured. The three bacterial strains were cultured on nutrient agar for 18 hours. Then, four well-isolated bacterial colonies were suspended in 0.9% NaCl physiological saline. This

suspension was adjusted to the McFarland 0.5 standard using a spectrophotometer, with an optical density (OD) of 0.08-0.1 at 625 nm, indicating approximately 1.5×10^8 CFU/ml (CA-SFM, 2013). A further dilution was made to achieve a concentration of 1.5×10^6 CFU/ml. The previously prepared aqueous and hydroethanolic extract solutions were diluted to 100 mg/mL with sterile distilled water. The ceftriaxone solution was prepared similarly at 1 mg/mL. All mixtures were thoroughly homogenized until lump-free. After the Mueller-Hinton agar solidified, the Petri dishes were inoculated by spreading 50 μL of each bacterial suspension. Wells 6 mm in diameter were punched into the agar surface and filled with 100 μL of the aqueous and hydroethanolic extracts. A ceftriaxone well was also placed in each dish as a positive control. The dishes were incubated at 37 °C for 24 hours. The inhibition zones were measured around each well using a vernier caliper (Kengne, 2019). All tests were performed in triplicate, and the bacterial strains' susceptibility to the extracts was classified based on the inhibition diameter (ID) as follows: non-sensitive ($\text{ID} \leq 8$ mm), sensitive ($9 \leq \text{ID} \leq 14$ mm), highly sensitive ($15 \leq \text{ID} \leq 19$ mm), and extremely sensitive ($\text{ID} \geq 20$ mm) (Moreira et al., 2005).

2.5.2. Determination of Minimum Inhibitory Concentrations (MIC)

The antibacterial activity of the aqueous and hydroethanolic extracts was assessed using the microdilution method in liquid medium as described by CLSI (2024). In each well of a 96-well microplate, 100 μL of Mueller-Hinton broth was added. Then, 100 μL of 8192 $\mu\text{g/mL}$ stock solutions of the extracts was added to the initial wells. For the antibiotic, an equal volume of the 1024 $\mu\text{g/mL}$ ceftriaxone solution was used. A 2-fold serial dilution was performed from these wells to obtain extract concentrations ranging from 4096 $\mu\text{g/mL}$ to 2 $\mu\text{g/mL}$. A 100 μL volume of bacterial inoculum, adjusted to 10^6 CFU/mL, was added to each well, resulting in a final density of 5×10^5 CFU/mL. The final volume per well was 200 μL , and all tests were conducted in triplicate. The third set of wells served as negative controls with only the culture medium and plant extracts. Additional wells served as positive controls for growth, containing only culture medium and inoculum. The microplates were incubated at 37°C for 24 hours. After incubation, 40 μL of Blue Alamar (0.5%), a microbial growth indicator, was added to each well, and the plates were incubated for another 30 minutes. A color change from blue to pink indicated bacterial growth. The MIC was defined as the lowest concentration of plant extract required to inhibit bacterial growth (CLSI, 2024). The third row, without Blue Alamar, was used to determine the minimal bactericidal concentration (MBC).

Interpretation of results

The interpretation of results followed the approach of Kuete (2010). They established that, for plant extracts, antibacterial activity is considered significant when the MIC is less than 100 $\mu\text{g/mL}$, moderate when it is between 100 $\mu\text{g/mL}$ and 625 $\mu\text{g/mL}$, and low when it exceeds 625 $\mu\text{g/mL}$. Specifically, for extracts from edible parts of the plant, activity is categorized as high if the MIC is below 100 $\mu\text{g/mL}$, significant if between 100 $\mu\text{g/mL}$ and 512 $\mu\text{g/mL}$, moderate if between 512 $\mu\text{g/mL}$ and 2048 $\mu\text{g/mL}$, low if the MIC is over 2048 $\mu\text{g/mL}$, and inactive if the MIC is greater than 10 mg/mL.

2.5.3. Determination of Minimum Bactericidal Concentrations (MBC)

In a microplate containing 150 μL of sterile Mueller-Hinton broth, 50 μL from the third-row wells corresponding to extract concentrations $> \text{MIC}$ was added. The mixture was incubated at 37 °C for 24 hours, then stained with Blue Alamar for 30 minutes. MBC refers to the lowest concentration of extract at which no color change was observed (Oussou et al., 2008). The bactericidal activity of the extract was evaluated by calculating the MBC/MIC ratio : if $\text{MBC/MIC} \leq 4$, the extract is bactericidal; if $\text{MBC/MIC} > 4$, the extract is bacteriostatic (Fauchere and Avril, 2002).

2.6. Evaluation of Antioxidant Properties

2.6.1. Anti-radical assay of 2,2-diphenyl-1-picrylhydrazine (DPPH)

The tests to evaluate anti-radical activity (DPPH) involved preparing extracts at concentrations of 0.25, 0.5, 1, 2, and 4 mg/mL. The free-radical scavenging ability of the extracts was assessed as described by Nyegue et al. (2016). For this, 50 μL of each stock solution at various concentrations was added to 1950 μL of methanolic DPPH solution in test tubes, resulting in a total volume of 2 mL and final concentrations of 0.1 mg/mL; 0.05 mg/mL; 0.025 mg/mL; 0.0125 mg/mL; and 0.00625 mg/mL. The tubes were then incubated in the dark at 25 °C for 30 minutes, after which absorbance was measured at 515 nm with a spectrophotometer (V-1100). All tests were performed in triplicate. A control tube containing 2 mL of methanolic DPPH solution without extracts was included. The antioxidant activity of the extracts was expressed relative to ascorbic acid and quercetin.

2.6.2. 2,2-azinobis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) Assay

This assay was performed as described by Re et al (1999). The ABTS radical discoloration test was conducted to evaluate free-radical scavenging ability. In each tube, 50 μL of the extract, diluted 10-fold, was added, followed by 1950 μL of the ABTS working solution. After 30 minutes of incubation, the absorbance was measured at 734 nm against a blank, in which the extract was replaced with 20 μL of water. The tests were performed in triplicate, with Ascorbic Acid used as the reference molecule.

2.6.3. Ferric Reducing Antioxidant Power assay (FRAP)

The antioxidant iron-reducing power was determined as previously described by Nyegue et al. (2016). Hence, 1950 μL of FRAP solution was added to the test tubes, followed by 50 μL of plant extract at different concentrations. The tests were carried out in triplicate. The mixture was incubated for 30 minutes in the dark, and the optical density was measured at 593 nm using a Jenway 6305 spectrophotometer.

2.6.4. Determination of total polyphenols content by the Folin-Ciocalteu assay

The total polyphenol content was assessed using the spectrophotometric method with the Folin-Ciocalteu reagent, as described by Chew et al. (2009). In the test tubes, 1.817 μL of distilled water, 115 μL of Folin-Ciocalteu reagent diluted to 1/10, and 345 μL of 15% sodium carbonate (Na_2CO_3) were added. The tubes were

vortexed after adding the extracts at different concentrations and then incubated for 2 hours; absorbance was measured at 765 nm. The calibration was performed using a freshly prepared aqueous solution of ascorbic acid, and the results were expressed in mg EAA/g DM. The reaction is described by the following equation.

2.6.5. Determination of the content of primary and secondary antioxidants

Use the optical density of the extract, which made it possible to obtain the SC_{50} from DPPH for the determination of the content of primary antioxidants or from FRAP for the determination of secondary antioxidants, which is projected on the trapping curve as a function of the concentration of ascorbic acid to determine the corresponding concentration of ascorbic acid. This concentration is then divided by the extract concentration to have the equivalent concentration of ascorbic acid per gram of dry extract (EAA/g extract) (Djova et al., 2018).

2.7. Statistical analysis

Results and statistical analyses were conducted using GraphPad Prism 8.0.1.244. Data are presented as mean $\pm$ standard deviation (SD) and analyzed with a one-way ANOVA using the Fisher test at a significance level of $p < 0.05$ with Stat Graphics Plus 5.0 for Windows. Graphs and tables of the various curves were generated using Microsoft Excel 2019 on Windows.

3. Results

3.1. Phytochemical screening

Various classes of compounds were detected in the leaves, stem barks, and roots of *Anthocleista schweinfurthii*. Phenols, triterpenes, and steroids were the most prevalent in all extracts (Table 1). Saponins were absent in the hydroethanolic and aqueous root extracts. The hydroethanolic leaf extracts were notably rich in phenols and anthocyanins, with alkaloids and anthraquinones also present. Furthermore, the aqueous bark extracts showed high levels of phenols, polyphenols, and flavonoids.

3.2. Antibacterial activities of plant extracts and ceftriaxone

3.2.1. Sensitivity of microbial strains to plant extract solutions.

The tested plant extracts showed antibacterial activity against two of the evaluated strains, specifically *Shigella sonnei*. (CMCC51630) and *Salmonella enterica* serovar Typhi (200836550). Among all the tested extracts, four hydroethanolic and aqueous leaf and root extracts out of six demonstrated inhibitory effects on at least one of the three microbial species tested (Table 2). Overall, the inhibition zone sizes on sensitive strains ranged from 17 ± 1.41 mm (aqueous leaf extract against *Salmonella enterica* serovar Typhi (200836550) to 21 ± 1.41 mm (hydroethanolic leaf extract against *Shigella sonnei* (CMCC51630). The aqueous and hydroethanolic stem bark extracts showed less activity compared to the other effective extracts. *Escherichia coli* (ATCC 25922) was resistant to all plant extracts. However, the reference antibiotic, ceftriaxone, exhibited the largest inhibition diameter of 44.5 ± 0.71 mm against *Shigella sonnei* (CMCC51630), 49 ± 1.41 mm against *Escherichia coli* (ATCC 25922), and 46.5 ± 0.71 mm against *Salmonella enterica* serovar Typhi (200836550).

Table 1. Phytochemical screening summary

Chemical compounds	Extracts of <i>Anthocleista schweinfurthii</i>					
	Aqueous extracts			Hydroethanolic extracts		
	Leaves	Barks	Roots	Leaves	Barks	Roots
Alkaloids	+	-	-	-	-	-
Phenols	++	++	++	++	++	++
Polyphenols	-	++	-	+	+	-
Tannins	++	-	-	+	-	-
Saponins	+	+	-	+	+	-
Flavonoids	-	++	-	+	+	-
Triterpènes	+	+	+	+	+	+
Steroids	+	+	+	+	+	+
Anthocyanins	+	-	-	++	+	-
Anthraquinones	-	-	-	-	-	-

Legend: (+) Presence of the compound; (++) Abundance of the compound; (-) Absence of the compound

3.2. Antibacterial activities of plant extracts and ceftriaxone

3.2.1. Sensitivity of microbial strains to plant extract solutions.

The tested plant extracts showed antibacterial activity against two of the evaluated strains, specifically *Shigella sonnei*. (CMCC51630) and *Salmonella enterica* serovar Typhi (200836550). Among all the tested extracts, four hydroethanolic and aqueous leaf and root extracts out of six demonstrated inhibitory effects on at least one of the three microbial species tested (Table 2). Overall, the inhibition zone sizes on sensitive strains ranged from 17 ± 1.41 mm (aqueous leaf extract against *Salmonella enterica* serovar Typhi (200836550) to 21 ± 1.41 mm (hydroethanolic leaf extract against *Shigella sonnei* (CMCC51630)). The aqueous and hydroethanolic stem bark extracts showed less activity compared to the other effective extracts. *Escherichia coli* (ATCC 25922) was resistant to all plant extracts. However, the reference antibiotic, ceftriaxone, exhibited the largest inhibition diameter of 44.5 ± 0.71 mm against *Shigella sonnei* (CMCC51630), 49 ± 1.41 mm against *Escherichia coli* (ATCC 25922), and 46.5 ± 0.71 mm against *Salmonella enterica* serovar Typhi (200836550).

3.2.2. Bacterial growth inhibition parameters (MIC, MBC, and MBC / MIC)

All the extracts tested exhibited antibacterial activity. Indeed, all extracts inhibited all tested bacteria, with MICs ranging from 64 to 512 $\mu\text{g/mL}$ (Table 3). The

hydroethanolic extract of the bark, although bactericidal on *Salmonella enterica* serovar Typhi (200836550) and *E. coli* (ATCC 25922), showed the best MICs at a value of 64 $\mu\text{g/mL}$ on *Shigella* spp (CMCC51630), and *Salmonella enterica* serovar Typhi (200836550), and therefore its antibacterial activity is said to be significant on these two strains ($\text{MIC} < 100 \mu\text{g/mL}$). Moderate inhibitions (when $100 \mu\text{g/mL} < \text{MIC} \leq 625 \mu\text{g/mL}$), interesting extracts of aqueous leaves, hydroethanolic leaves, and hydroethanolic roots active on all strains, as well as aqueous extracts of bark and roots active on *Shigella* spp. (CMCC51630) and *E. coli* (ATCC 25922) with MIC values ranging from 128 to 512 $\mu\text{g/mL}$ for each extract. The hydroethanolic bark extract had an MIC of 256 $\mu\text{g/mL}$. The hydroethanolic roots extracts, although not very active compared to the others, showed interesting effects on *Salmonella enterica* serovar Typhi (200836550) which appears to be the most sensitive species, since in the presence of all the extracts, the values of the MBC/MIC ratio obtained were always 1 for five extracts and 2 for only one (aqueous leaves), followed by *E. coli* (ATCC 25922) with 4 out of three extracts. *Shigella* spp. (CMCC51630) appear to be the most resistant species to plant extracts, with higher MIC values compared to other strains. The MBCs detected in this work ranged from 64 to 1024 $\mu\text{g/mL}$, depending on the extract and bacterial strain.

All extracts exhibited a bactericidal effect against *Salmonella enterica* serovar Typhi (200836550), with MBC/MIC ratios ≤ 4 . The aqueous and hydroethanolic extracts of the leaves and bark were also bactericidal on *E. coli* (ATCC 25922). The aqueous extract of the roots exhibited bacteriostatic activity ($\text{MBC} / \text{MIC} > 4$) on

Table 2. Inhibition zone diameter of *Anthocleista schweinfurthii* extracts and ceftriaxone

Extracts / Ceftriaxone		Inhibition diameters		
		<i>Shigella sonnei</i> (CMCC51630)	<i>Escherichia coli</i> (ATCC 25922)	<i>Salmonella typhi</i> (200836550)
Hydroethanolic	Leaves	21 ± 1.41	/	/
	Stem barks	/	/	/
	Roots	19 ± 1.41	/	/
Aqueous	Leaves	/	/	17 ± 1.41
	Stem barks	/	/	/
	Roots	/	/	19 ± 1.41
Ceftriaxone		44.5 ± 0.71	49 ± 1.41	46.5 ± 0.71

Table 3. Inhibition parameters of bacterial growth by plant extracts and ceftriaxone

Extracts / Ceftriaxone		Inhibition parameters of bacterial growth (µg/mL)	Bacterial species			PBSS (%)
			Shigella sonnei. (CMCC51630)	Salmonella typhi (200836550)	E. coli (ATCC 25922)	
Aqueous	Leaves	MIC	512	256	64	100
		MBC	/	512	256	/
		MBC /MIC	/	2	4	/
	Stem barks	MIC	128	128	256	100
		MBC	/	128	1024	/
		MBC /MIC	/	1	4	/
	Roots	MIC	128	64	512	100
		MBC	1024	64	/	/
		MBC /MIC	8	1	/	/
	Hydroethanolic	Leaves	MIC	512	256	256
MBC			/	256	1024	/
MBC /MIC			/	1	4	/
Stem barks		MIC	64	64	256	100
		MBC	/	64	1024	/
		MBC /MIC	/	1	4	/
Roots		MIC	128	256	512	100
		MBC	/	256	/	/
		MBC /MIC	/	1	/	/
Ceftriaxon		MIC	32	2	4	100
	MBC	32	8	4	/	
	MBC /MIC	1	4	1	/	

Legend: MIC or MBC >1024 $\mu\text{g} / \text{mL}$; PBSS (%): percentage of bacteria sensitive to each substance. In bold: best values of MIC, MBC / MIC, and PBSS

Shigella spp. (CMCC51630) with a better MIC (64 $\mu\text{g/mL}$) on *Salmonella enterica* serovar Typhi (200836550). However, although some extracts showed activities similar to Ceftriaxone (reference antibiotic), the latter was bactericidal ($\text{MBC/MIC} \leq 4$) on all the bacterial strains tested. In general, it appears from Table 3 that all the extracts were active; however, the hydroethanolic extract of the bark was the most active with the lowest MIC values as well as an MBC/MIC ratio ≤ 4 .

3.3. In vitro evaluation of the antioxidant activity of aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii*

3.3.1. Evaluation of the anti-free radical power by the DPPH test

The SC_{50} of all extracts was determined by plotting the scavenging percentage as a function of extract, quercetin, and ascorbic acid concentrations. From this, the EC_{50} was obtained and used to determine the AP reported in Table 4. The aqueous root extracts exhibit the strongest antioxidant activity, with an anti-free-radical power of $2,338 \pm 0,011$. However, the antioxidant activities of the extracts were lower than those of the reference molecules quercetin and ascorbic acid, with APs of 25.61 ± 0.001 and 23.305 ± 0.002 , respectively.

3.3.2. Radical test 2,2-Azino-bis(3-ethylbenzothiazoline) -6-sulfonic (ABTS +)

The anti-free radical activity evaluated by the ABTS test is expressed in terms of the concentration of the extract, which makes it possible to trap 50% of the ABTS radical (SC_{50}), the effective concentration EC_{50} (expressed in mg Ex/g of ABTS), and the anti-free radicals (AP) obtained are

presented in Table 4. The aqueous root extracts of *A. schweinfurthii* had the best anti-free radical activities with AP value of 3.638 ± 0.001 . However, this extract exhibited anti-free-radical activity lower than that of the reference molecule (ascorbic acid), with an AP of 10.4. The summary of the anti-free-radical activities in the DPPH and ABTS assays is given in Table 4. Statistically, ascorbic acid and quercetin have the same anti-free radical activity and superior activity to the two extracts of *A. schweinfurthii* evaluated. On the other hand, it was observed that the aqueous root extracts of *A. schweinfurthii* exhibited the best anti-free radical activity through the DPPH and ABTS tests in comparison with the hydroethanolic extracts.

3.3.3. In vitro evaluation of the reducing power by the FRAP assay

The regression line $y = ax + b$ for the ascorbic acid curve allowed us to express the different extracts in mg EAA/g DM. Figure 1 below summarizes the reducing powers of the aqueous and hydroethanolic extracts of *A. schweinfurthii*. The aqueous root extracts with a reducing capacity of 427.57 mg EAA/g DM were found to have a

Table 4. Summary of the anti-free radical assay

Substances	AP/DPPH	AP/ABTS
Hydroethanolic roots	$0.766 \pm 0.001\text{a}$	$1.018 \pm 0.001\text{e}$
Aqueous roots	$2.338 \pm 0.011\text{b}$	$3.638 \pm 0.001\text{a}$
Ascorbic acid	$23.305 \pm 0.002\text{c}$	10.4c
Quercetin	$25.61 \pm 0.001\text{d}$	/

Legend: The values that have the same letters are statistically identical, while those that have different letters are statistically different with a significance level of $P < 0.05$.

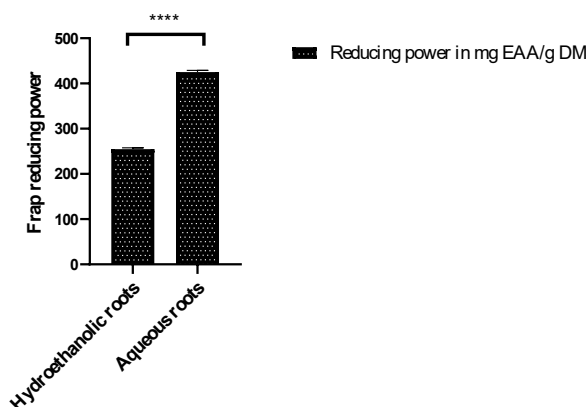


Figure 1. Frap reducing power of roots, aqueous and hydroethanolic extracts of *A. schweinfurthii* (there is a statistically significant difference between the samples tested (****, $p < 0.0001$))

metal chelating activity higher than that of the hydroethanolic root extracts of 254.53 ± 0.97 mg EAA/g DM.

3.3.4. Determination of total polyphenols and correlation with the antioxidant activity of the extracts

The quantitative analysis of the total polyphenols (Q polyphenols) was determined from the linear regression equation of the calibration curve of ascorbic acid. These results are expressed in mg equivalent of ascorbic acid per g of dry matter.

The determination of polyphenol content by spectrophotometry using the Folin-Ciocalteu reagent enabled evaluation of the extracts' antioxidant activity *in vitro*. The contents of primary or curative antioxidants and secondary or preventive antioxidants of the extracts of *Anthocleista schweinfurthii* were determined and summarized in Table 6. The hydroethanolic root extracts of *A. schweinfurthii* have the highest polyphenol contents of 441.49 mg EAA/g extract and mainly consist of secondary antioxidants with the contents of 127.27 ± 0.52 mg EAA/g extract. The aqueous root extracts mainly consist of secondary antioxidants, with a content of 213.8 mg EAA/g extract.

4. Discussions

This study was conducted to identify new plant-derived compounds to fight bacteria responsible for gastroenteritis and to mitigate oxidative stress. It achieved this by evaluating the antibacterial and antioxidant activities of aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii* against *Escherichia coli* (ATCC 25922) and *Shigella sonnei*. (CMCC51630), and *Salmonella enterica* serovar Typhi (200836550), which causes gastroenteritis. Phytochemical screening of the extracts revealed the presence of phenols, polyphenols, tannins, triterpenes, alkaloids, saponins, steroids, anthocyanins, and flavonoids. Phenols were abundant and predominant in all aqueous and hydroethanolic extracts. These findings differ from those of Mbouangouere et al (2007) and Djova et al. (2018), who identified alkaloids and xanthenes as the main compounds in *A. schweinfurthii*. This discrepancy may be due to polar solvents, such as ethanol/water systems, which effectively extract highly polar compounds; abiotic factors may also influence the presence of active biomolecules in the extracts (Bruneton, 1999; Didem et al., 2009). Saponins

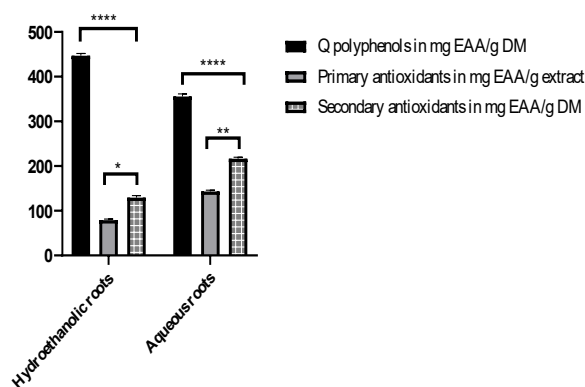


Figure 2. Summary of the primary antioxidants, secondary antioxidants, and the total amount of polyphenols (There is a statistically significant difference between the samples tested (****, $p < 0.0001$, (**, $p = 0.031$, (*, $p = 0.037$))

were absent in the aqueous root extract but present in the other five extracts of *A. schweinfurthii*, confirming Djova et al. (2018), who found saponins in the aqueous extracts of the leaves and bark. These chemical compounds possess antibacterial and antioxidant activities.

The antibacterial assay showed that the aqueous and hydroethanolic extracts of *A. schweinfurthii* inhibit the growth of pathogenic bacteria, including *E. coli* (ATCC 25922), *Shigella sonnei*. (CMCC51630), and *Salmonella enterica* serovar Typhi (200836550), which can cause serious gastrointestinal infections. The sensitivity test indicated that only a few extracts showed activity against the different bacterial strains on solid media, with inhibition diameters ranging from 17 ± 1.41 to 21 ± 1.41 mm. On the other hand, good activity was observed in liquid media across all bacterial strains, with MICs ranging from 64 to 512 $\mu\text{g/mL}$. This could be explained by the fact that, in a liquid medium, bacteria are in direct contact with the extract, which might not fully diffuse on agar (Afagnigni et al., 2016). The hydroethanolic extract of the bark exhibited greater activity, with an MIC of 64 $\mu\text{g/mL}$ against *Shigella sonnei*. (CMCC51630), and *Salmonella enterica* serovar Typhi (200836550), as well as a bactericidal effect on *Salmonella enterica* serovar Typhi (200836550), (MBC/MIC = 1). This significant activity, according to Kuete's scale (2010), can be attributed to the extract's chemical composition, which is rich in phenols and likely acts synergistically with other metabolites present in the plant. The antibacterial activity of the phenolic-rich plant extract is primarily attributed to the ability of phenolic compounds to compromise bacterial membrane integrity, induce the leakage of vital intracellular components, and denature essential enzymes (Daglia, 2012).

During microbial infections, the production of reactive oxygen species and other free radicals is inevitable and may lead to oxidative stress (Alfadda and Sallam, 2012).

There is particular interest in basic research on new sources of antioxidants because previous studies have shown that antioxidants can reduce the reactivity of ROS (Reactive Oxygen Species). Many compounds from the plant world, such as polyphenols, possess potent antioxidant properties that help mitigate the harmful effects of ROS (Soobrattee et al., 2013). The anti-free radical activity was assessed through the DPPH and ABTS tests. The aqueous extract of the roots exhibited the strongest anti-free-radical activity in

the DPPH and ABTS assays. The anti-free-radical power, as determined by the DPPH and ABTS assays, was $2,338 \pm 0,011$ and $3,638 \pm 0,001$, respectively. However, the evaluation of the anti-free radical activity with the ABTS method showed that the aqueous roots extract of *A. schweinfurthii*, with an AP (anti-free radical power) of $3,638 \pm 0,001$, has an anti-free radical activity statistically greater ($p < 0.05$) than that of extracts from the aqueous roots of *A. schweinfurthii* with the DPPH assay, with an AP of $2,338 \pm 0,011$. The anti-free radical activity of the extracts can be justified by the presence of biomolecules identified as amentoflavone and agathisflavone, which belong to the flavonoid family in these extracts (Firuzi et al., 2005). Indeed, these molecules contain many OH groups and can act as hydrogen donors, readily inducing electron delocalization within the molecule and stabilizing the phenoxy radical structure (Soobrattee et al., 2013). The difference in activity observed between the extracts in the DPPH and the ABTS test could be explained by the fact that DPPH is most often solubilized in methanol and ethanol, and the aqueous extracts have low solubility in the DPPH solution, while the ABTS has the advantage of being soluble in organic and aqueous solvents; therefore, it is usually used to evaluate the anti-free radical activities of aqueous extracts, unlike the DPPH method which is more suitable for the evaluation the anti-free radical activity of extracts obtained with an organic solvent (Emad et al., 2013). The evaluation of antioxidant activity also included assessing the reducing power of the extracts using the FRAP test, which measures a molecule's or extract's ability to reduce ferric ions. At the end of the FRAP test, the aqueous root extracts of *A. schweinfurthii* had the highest chelating activity with a reducing power of 427.57 mg EAA/g extract. According to Soobrattee et al. (2013), biflavonoids have many aromatic groups rich in electrons, as well as unsaturated carboxyl groups of β and α nature, which increase their antioxidant capacity because they can easily chelate heavy metals or deactivate active oxygen by transfer of an electron and rapid isomerization to stabilize the structure of the radical formed. The preventive study of oxidative stress in *A. schweinfurthii* extracts has shown that the hydroethanolic root extracts have the highest polyphenol content (441.49) and are primarily composed of secondary or preventive antioxidants (127.27 ± 0.52). Indeed, by chelating heavy metals or deactivating reactive oxygen species, secondary antioxidants are said to be preventive and to act on other oxidative factors to prevent the propagation of the radical chain reaction (Gulsen et al., 2015). Thus, the hydroethanolic root extracts of *A. schweinfurthii* would have a strong preventive capacity against oxidative stress due to their higher secondary antioxidant content compared to their primary antioxidant content. The aqueous root extracts contain both primary and secondary antioxidants ($213,8 \pm 0,8$ mg EAA/g DM and $140,47 \pm 0,33$ mg EAA/g DM, respectively). Primary antioxidants have multiple hydroxyl groups attached to one or more aromatic rings and can scavenge free radicals by donating a hydrogen atom, whereas chelating antioxidants have high isomerization capacity and can therefore donate electrons to activated oxygen and heavy metals to prevent oxidation (Oukalha et al., 2018). However, the aqueous root extract had the highest secondary antioxidant content (213.8 mg EAA/g DM). In general, all aqueous and hydroethanolic extracts of *A. schweinfurthii* could be used as a preventive and curative measure in the treatment of oxidative stress and infectious diseases. The polyphenol

content is correlated with antioxidant activity (Djova et al., 2018).

The results presented in this paper show that the aqueous root extracts of *A. schweinfurthii* have the best antioxidant activities *in vitro*. These extracts have higher secondary antioxidant content than primary antioxidants, which justifies their greater reducing power (427.57 mg EAA/g extract) compared with their anti-radical power (3.638 ± 0.001). These extracts would act as antioxidants, scavenging ROS and preventing and repairing ROS-induced damage, thereby strengthening immune defenses and reducing the risk of gastroenteritis, cancer, and degenerative diseases. Studies carried out by Djova et al. (2018) showed that the aqueous extracts of the stem bark contained more antioxidants compared to the aqueous leaf extracts. The aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii* not only exhibited antibacterial activity against the bacterial strains tested but also demonstrated effective antioxidant properties, scavenging ROS and deactivating heavy metals to prevent ROS formation, thereby helping to prevent and combat oxidative stress and gastroenteritis. The abundance of primary (curative) and secondary (preventive) antioxidants makes *A. schweinfurthii* a major asset in the prevention and treatment of gastroenteritis in particular and infectious diseases in general.

5. Conclusion

The phytochemical screening of the aqueous and hydroethanolic extracts of *Anthocleista schweinfurthii* revealed the presence of active compounds, including phenols, steroids, saponins, triterpenes, tannins, flavonoids, and anthocyanins, all of which exhibit antibacterial properties. The antibacterial assay demonstrated that both extracts inhibit the growth of *Escherichia coli* (ATCC 25922), *Shigella sonnei*. (CMCC51630), and *Salmonella enterica* serovar Typhi (200836550). Among them, the hydroethanolic stem bark extract showed the highest antibacterial activity compared to the aqueous extracts. The results indicated that *A. schweinfurthii* contains a significant amount of total polyphenols, which likely contribute to its notable antioxidant activity. These findings support the traditional use of *A. schweinfurthii* in Cameroon to treat infectious diseases, particularly gastroenteritis, and suggest that it is a valuable source of antioxidant biomolecules for further exploration. Moving forward, this research should progress to *in vivo* studies, the isolation of active bioactive compounds, and a thorough evaluation of the toxicological effects of these extracts.

Conflict of Interest

Authors declared no conflicts of interest regarding the publication of this paper.

Authors' Contribution

Kengne and Djova made data analysis and drafted the manuscript; Ngongang made critical revisions to the manuscript; Lebika conducted experiments; Nyegue and Voundi designed and initiated the study

Acknowledgments

The authors acknowledge the assistance of the National Herbarium of Cameroon and the Centre for the Study and Control of Communicable Diseases (CSCCD) for their technical support.

References

- Afagnigni AD, Nyegue MA, Ndoeye FCF, Voundi OS, Fonkoua C, Etoa F-X (2016). Antibacterial and antioxidant activities of ethanolic leaves extracts of *Dissotis multiflora triana* (Melastomataceae). International Journal of Pharmaceutical Sciences and Drug Research 8(1): 50-56
- Alfadda AA, Sallam RM (2012). Reactive oxygen species in health and disease. Journal of Biomedicine and Biotechnology 1(14): 936486-936486.
- Beaudeux JL, Durand G (2011). Medical Biochemistry – Present markers and perspectives. 2e Ed, Medicine sciences publications, lavoisier.
- Bruneton J (1999). Pharmacognosie: Phytochemistry, medicinal plants. Lavoisier Technics & Documentation, Paris 2: 310-313.
- CA-SFM (2013). Antibigram Committee of the French Society of Microbiology, Antibigram: recommandation <http://www.sfm.asso.fr>.
- Chew YL, Goh JK, Lim YY (2009). Assessment of in vitro antioxidant capacity and polyphenolic composition of selected medicinal herbs from Leguminosae family in peninsular Malaysia. Journal of Food Chemistry 116: 13-18.
- Christophe M, Frida L, Cline N, Zacharie S, Emilie N, Vernyuy PT (2015). Evaluation of acute and subacute toxicity of stem bark aqueous extract of *Anthocleista schweinfurthii* (Loganiaceae). World Journal of Pharmacy and Pharmaceutical Sciences 4: 197-208.
- CLSI (2024). Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically. Wayne: M07, Clinical and Laboratory Standards Institute.
- Daglia M (2012). Polyphenols as antimicrobial agents. Current Opinion in Biotechnology 23(2): 174-181.
- Didem S, Melike E, Meral O, Mahmut KS (2009). Free radical scavenging and antimicrobial activities of some *Geranium* species. Journal of the Faculty of Pharmacy 28: 115-125.
- Djova SV, Nyegue MA, Afagnigni AD, Etoa FX (2018). In vitro antioxidant activity, cytotoxicity and genotoxicity of extracts from the leaves and barks of *Anthocleista schweinfurthii* Gilg (Loganiaceae). Asian Journal of Research in Biological and Pharmaceutical Sciences 6(2): 58-69.
- Dongmo NA, Nganso DYO, Nkwengoua TE, Boda M, Voundi OS, Etoa FX, Nyasse S (2015). In-vitro testing of extracts and fractions from two Cameroonian medicinal plants on bacteria gastroenteritis. American Journal of Phytomedicine and Clinical Therapeutics 3(9): 575-588.
- Emad AS and Sanaa MMS (2013). Comparison of DPPH and ABTS assays for determining the antioxidant potential of water and methanol extracts of *Spirulina plantensis*. Indian Journal of Geo-Marine Sciences 42(5): 556-564.
- Evans WC (2000). Trease and Evans' Pharmacognosy. 15th Edition, London : WB Saunders.
- Fauchère JL, Avril JL (2002). Bactériologie générale et médicale. Paris : Éditions Ellipses.
- Firuzi O, Lacanna AR, Petrucci R, Marrosu G, Saso L (2005). Evaluation of the antioxidant activity of flavonoids by ferric reducing antioxidant power assay and cyclic voltammetry. Biochimica et Biophysica Acta 1721(1-3): 174-184.
- Gulsen T, Mehmet O, Mehmet ED, Aziz T (2015). Antioxidant and anticholinesterase activities of five wild mushroom species with total bioactive contents. Pharmaceutical Biology 53(6): 824-830.
- Harborne JB (1998). Phytochemical methods a guide to modern technique of plants analysis. Springer Dordrecht, ISBN: 978-0-412-57260-9
- Kengne GL, Nyegue MA, Moni NEDF, Etoa FX (2019). Antibacterial activity of selected plant essential oils on airborne bacteria and mode of action on membrane integrity. American Journal of Essential Oils and Natural Products 7(1): 28-35.
- Kuete V (2010). Potential of Cameroonian plants and derived products against microbial infections. A review. Planta Medica 76(14): 1479-1491.
- Kuete V, Djeussi DE, Mbaveng AT, Zeino M, Efferth T (2016). Cytotoxicity of 15 Cameroonian medicinal plants against drug sensitive and multi-drug resistant cancer cells. Journal of Ethnopharmacology 186: 196-204.
- Mbouangouere RN, Tane P, Ngamga D, Khan SN, Choudhary MI, Ngadjui BT (2007). New steroid and α -glucosidase inhibitors from *Anthocleista schweinfurthii*. Research Journal of Medicinal Plant 1(3): 106-111.
- Mezui C, Longo F, Nkenfou C, Sando Z, Ndeme E, Tan PV (2015). Evaluation of acute and sub-acute toxicity of stem bark aqueous extract of *Anthocleista schweinfurthii* (Loganiaceae). World Journal of Pharmacy and Pharmaceutical Sciences 4(3): 197-208.
- Moreira MR, Ponce AG, Del Valle CE, Roura SI (2005). Inhibitory parameters of essential oils to reduce a foodborne pathogen. Lebensmittel-Wissenschaft und-Technologie 38(5): 565-570.
- Mubindukila REN, Ngbolua KN, Mpiana PT, Ashande MC, Baholy R, Fatiany PR, Ekutsu GE, Gbolo ZB (2014). In vitro assessment of antibacterial and antioxidant activities of a Congolese medicinal plant species *Anthocleista schweinfurthii* Gilg (Gentianaceae). Journal of Modern Drug Discovery and Drug Delivery Research 1(3): 1-6.
- Nkouam F, Momeni J, Tchamango S, Darchen A, Ngassoum M (2022). Antioxidant and antibacterial activities of two xanthenes derivatives isolated from the leaves extract of *Anthocleista schweinfurthii* Gilg (Loganiaceae). Physical Sciences Reviews 7(12): 1345-1352.

- Nyegue MA, Ngo MJ, Djova SV, Messi AN, Voundi OS, Pegnyemb DE, Etoa FX (2016). Evaluation of the antioxidant activity of the leaves, stem-barks extracts and fractions of *Ochna schweinfurthiana* F.Hoffm (*Ochnaceae*). African Journal of Pharmacy and Pharmacology 10(17): 370-378.
- Okou OC, Yapo S, Kporou K, Baibo G, Monthau S, Djaman A (2018). Evaluation of the antibacterial activity of leaf extracts of *Solanum torvum* Swartz (*Solanaceae*) on the in vitro growth of 3 Enterobacteria strains. Journal of Applied Biosciences 122: 12282-12290.
- Onzo CF, Azokpota P, Agbani P, Gbaguidi F, Hounhouigan JD, Kossou D (2014). Physiochemical, phytochemical characteristics and toxicity of plant species used as food packaging in West Africa. International Journal of Biological and Chemical Sciences 8(4): 1504-1516.
- Oukalha A, Zekhnini A, Bouhaimi A, Tahrouch S, Hatimi A (2018). Anti-inflammatory Activity of Methanolic Extract from *Pistacia atlantica* Desf. Leaves. Pharmacognosy Journal 10(1): 71-76.
- Oussou KR, Yolou S, Boti JB, Guessennnd KN, Kanko C, Ahibo C, Casanova J (2008). Chemical study and antidiarrhea activity of essential oils from two aromatic plants from Ivory Coast pharmacopeia. European Journal of Scientific Research 24(1): 94-103.
- Prakash V, Mishra PK, Mishra M (2009). Screening of medicinal plant extracts for antioxidant activity. Journal of Medicinal Plants Research 3: 608-612.
- Re S, Link EJ, Bui HH, Wang R (1999). Quantitative structure-activity relationship analysis of phenolic antioxidant. Free Radical Biology and Medicine 26(3-4): 285-294.
- Sofowara A (1993). Medicinal Plants and Traditional Medicine in Africa. 2nd Edition, Ibadan: Spectrum Books Ltd.
- Soobrattee MA, Neergheen VS, Luximon-Ramma A, Aruoma OI, Bahoru T (2013). Phenolic as potential antioxidant therapeutic agents: mechanism and actions. Mutation Research 11(579): 1-2.
- WHO (2002). WHO strategies for traditional medicine from 2002-2005. Geneva: World Health Organisation.