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Evaluation of Antioxidant and Antibacterial Potential of Alkaloids Fraction of *Newboulda Laevis* Leaf

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ABSTRACT

The alkaloid leaf fraction of Newbouldia laevis*, a plant widely used in traditional medicine for wound healing and infection control, was evaluated for its antioxidant and antibacterial activities alongside molecular docking analysis to predict possible mechanisms of action. Antioxidant capacity was assessed using hydroxyl radical, nitric oxide, DPPH radical scavenging, and lipid peroxidation inhibition assays. Antibacterial activity was tested against* Staphylococcus aureus, Salmonella typhi, Pseudomonas aeruginosa, *and* Escherichia coli *using agar well diffusion, minimum inhibitory concentration (MIC), and minimum bactericidal concentration (MBC) methods. The extract showed strong, concentration-dependent radical scavenging effects, reaching maximum inhibition at 320 µg/mL, particularly in DPPH (79.10%) and lipid peroxidation (86.90%) assays. IC_{50} values ranged from 92.70 µg/mL for DPPH to 382.90 µg/mL for hydroxyl radicals, confirming substantial antioxidant potential. The antibacterial result showed dose-dependent inhibition, with* S. aureus *showing the highest susceptibility (14.90 mm inhibition zone at 400 mg/mL). Bactericidal effects were observed at 50 mg/mL against all organisms, indicating both bacteriostatic and bactericidal actions, with Gram-positive bacteria showing greater sensitivity. The findings validate the ethnomedicinal use of* N. laevis *and highlight its potential as a source of lead compounds for developing plant-based therapies against oxidative stress and bacterial infections.*

Keywords: Antibacterial, Antioxidant, alkaloid fraction *Newbouldia laevis,* susceptibility

INTRODUCTION

Oxidative stress and microbial infections remain major global health challenges because both contribute significantly to chronic diseases and treatment-resistant infections. Reactive oxygen species (ROS) generated during oxidative stress can damage DNA, proteins, and lipids, thereby contributing to the development of cancer, cardiovascular diseases, and neurodegenerative disorders (Sies & Jones, 2020; Sies et al., 2022). At the same time, the rapid rise of antibiotic-resistant pathogens has intensified the search for novel and effective antibacterial agents. In this context, natural products particularly plant-derived alkaloids have gained increasing attention due to their strong antioxidative and antimicrobial activities (Porras et al., 2020; Abdallah et al., 2023).

Newbouldia laevis, commonly known as the African Border Tree or "tree of life," belongs to the Bignoniaceae family and is widely distributed in West Africa. It has long been used in traditional African medicine for treating fever, dysentery, wounds, and microbial infections (Kanu et al., 2018). Phytochemical studies reveal that the plant is rich in secondary metabolites such as alkaloids, phenols, saponins, and flavonoids, which underpin its diverse pharmacological activities (Oke et al., 2020). Among these compounds, alkaloids are particularly important because of their pharmacological versatility, including antioxidative, antimicrobial, analgesic, and anti-inflammatory properties (Peter et al., 2022; Sibri et al., 2023).

Plant-derived alkaloids demonstrate strong antioxidant activity through mechanisms such as free-radical scavenging, metal-ion chelation, and inhibition of lipid peroxidation (Chukwuma et al., 2023). Their antioxidative capacity is commonly evaluated using in vitro assays including the DPPH radical scavenging assay, ferric reducing antioxidant power (FRAP) assay, and total antioxidant capacity (TAC) assay, which collectively assess the ability of plant extracts to neutralize oxidative stress (Ramabulana, 2016). Previous investigations have already shown that alkaloids from Newbouldia laevis possess notable radical-scavenging activity, suggesting a protective role against oxidative damage (Flieger et al., 2021).

Beyond antioxidant potential, alkaloids from Newbouldia laevis exhibit significant antibacterial activity. Studies report inhibitory effects against both Gram-positive and Gram-negative bacteria, including Escherichia coli, Staphylococcus aureus, and Pseudomonas aeruginosa, which are pathogens commonly implicated in human infections (Kuete et al., 2007; Usman and Osuji, 2007; Akerele et al., 2011). The antibacterial mechanisms of alkaloids typically involve disruption of microbial cell walls, inhibition of protein synthesis, and interference with DNA replication, ultimately leading to cell death (Yan et al., 2021; Abookleesh et al., 2022). Given the growing threat of antimicrobial resistance, plant alkaloids represent promising alternatives to conventional antibiotics (Arip et al., 2022). In view of the phytochemical richness and therapeutic promise of Newbouldia laevis, this study aims to evaluate the antioxidant and antibacterial activities of its alkaloid fraction. In vitro assays will be used to assess free-radical scavenging, oxidative stress reduction, and antibacterial effects against pathogenic bacteria. The findings are expected to expand current knowledge on the medicinal value of *Newbouldia laevis* and support its potential as a source of natural antioxidant and antibacterial agents.

MATERIALS AND METHODS

Plant Collection and Preparation

Fresh leaves of *N. laevis* were collected from the premises of Michael Okpara University of Agriculture, Umudike (MOUAU), Nigeria, in August 2023 and authenticated by Dr. G. Omosun of the Department of Plant Science and Biotechnology, MOUAU. A voucher specimen (OANL0232023) was deposited in the herbarium of the same department and herbarium accession number MOUAU/PSB/HERB/2023/023 was assigned. The leaves were washed with tap water, air-dried at room temperature (25°C), and then ground into a fine powder using an electric blender.

Extraction and Preparation of the alkaloids-Rich Fractions

A total of 360 g of the powdered sample was extracted by maceration in 1.2 L of absolute methanol for 72 hours. The residue (filter cake) was subsequently washed with an additional 600 mL of methanol. The combined methanol extract was concentrated using a rotary evaporator at 45 °C to obtain the crude extract. The concentrated extract was then partitioned between 100 mL of chloroform and 50 mL of 0.1 M hydrochloric acid (HCl) using a separating funnel. The lower organic layer was discarded, while the aqueous acidic layer was retained. This aqueous layer was basified with ammonia and further partitioned with 80 mL of chloroform. The lower aqueous layer was discarded, and the chloroform layer containing the alkaloid-rich fraction was collected. The chloroform fraction was finally evaporated to dryness on a water bath to obtain the alkaloid-rich extract (Uwah et al., 2013).

Antimicrobial activity by Agar well diffusion method

The agar well diffusion technique is widely employed to evaluate the antimicrobial activity of plant and microbial extracts. In this study, the procedure described by Prabuseenivasan et al. (2006) was used with slight modifications. The alkaloid fraction of Newbouldia laevis was tested for antibacterial activity against selected bacterial strains, including the Gram-negative organisms Escherichia coli, Salmonella typhimurium, and Pseudomonas aeruginosa, as well as the Gram-positive bacterium Staphylococcus aureus. Each bacterial strain was cultured in nutrient broth at 37 °C for 24 hours, after which the turbidity of the suspension was adjusted to match the 0.5 McFarland standard (approximately 1.5×10^8 CFU/mL). Mueller–Hinton agar plates (Condalab, Spain) were uniformly inoculated by evenly spreading the standardized microbial suspension across the agar surface. Sterile wells of about 7 mm diameter were then created aseptically using autoclaved micropipette tips. A solution of the alkaloid fraction (0.25 mg/mL) was introduced into the wells, and the plates were incubated at 37 °C for 24 hours. Antibacterial activity was determined by measuring the diameter of the clear zones of inhibition (in millimeters) surrounding each well.

Determination of total alkaloids content:

Total alkaloid content was determined using the method described by Sharma et al. (2020) with slight modifications. A known weight (1.0 g) of the alkaloid-rich extract was accurately measured and transferred into a 250 mL beaker. The sample was dispersed in 40 mL of 10% acetic acid in ethanol, covered with aluminum foil, and allowed to stand for 4 hours at room temperature with occasional stirring to ensure complete extraction of alkaloids. The mixture was filtered using Whatman No. 1 filter paper, and the filtrate was concentrated on a water bath at approximately 60 °C until the volume was reduced to one-quarter of the original volume. Concentrated ammonium hydroxide solution was then added dropwise to the extract until precipitation was complete, indicating the formation of alkaloid precipitates. The resulting precipitate was allowed to settle, after which it was collected by filtration using pre-weighed filter paper. The residue was washed with dilute ammonium hydroxide to remove residual impurities and then dried to constant weight in an oven at 60 °C. The total alkaloid content was calculated gravimetrically and expressed as a percentage of the initial sample weight using the formula:

$$\%\, Total\ Alkaloid\ content = \frac{[weight\ of\ dried\ alkaloid\ precipitate}{\text{weight of sample}}\ x\ 100$$

Evaluation of In Vitro Antioxidant Activity

Determination of hydrogen peroxide scavenging capacity: The hydrogen peroxide (H_2O_2) scavenging activity of the extract was determined using the method described by Srinivasan et al. (2022) with slight modifications. A 40 mM hydrogen peroxide solution was prepared in phosphate buffer (0.1 M, pH 7.4). Different concentrations of the extract (e.g., 20–100 µg/mL) were prepared in distilled water or appropriate solvent. Ascorbic acid was used as the reference standard. An aliquot of 0.6 mL of the H_2O_2 solution was mixed with 1.0 mL of the extract solution at each concentration. The reaction mixture was vortexed and incubated at room temperature for 10 minutes. A control solution containing hydrogen peroxide without the extract was prepared simultaneously. After incubation, the absorbance of the reaction mixture was measured at 230 nm using a UV–Visible spectrophotometer against a blank solution containing phosphate buffer without hydrogen peroxide. The percentage scavenging activity of hydrogen peroxide by the extract was calculated using the following equation:

$$\%\, \mathrm{H_2O_2}\ scavenging\ potential = \frac{[(A_{Control} - A_{sample}}{A_{control}}\ x\ 100$$

Determination of nitric oxide (NO) scavenging activity: The nitric oxide (NO) scavenging activity of the extract was determined using the method described by Alisi et al. (2008) with slight modifications. Sodium nitroprusside (10 mM) was prepared in phosphate buffer saline (PBS, pH 7.4). Different concentrations of the extract (e.g., 20–100 µg/mL) were prepared in an appropriate solvent. Ascorbic acid was used as the reference standard. A reaction mixture containing 2.0 mL of sodium nitroprusside solution and 0.5 mL of the extract at various concentrations was incubated at room temperature for 150 minutes under light to generate nitric oxide radicals. A control containing sodium nitroprusside without extract was prepared simultaneously. After incubation, 1.0 mL of the reaction mixture was transferred into a clean test tube and mixed with 1.0 mL of Griess reagent (prepared by mixing equal volumes of 1% sulfanilamide in 2% phosphoric acid and 0.1% N-(1-naphthyl) ethylenediamine dihydrochloride). The mixture was allowed to stand for 10 minutes at room temperature for color development. The absorbance of the resulting chromophore was measured at 546 nm using a UV–Visible spectrophotometer against a blank. The percentage nitric oxide scavenging activity was calculated using the formula:

$$\%\, NO\ scavenging = \frac{[(A_{control} - A_{sample}}{A_{control}}\ x\ 100$$

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay: The free radical scavenging activity of the extract was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay according to the method of Brand-Williams et al. (1995) with slight modifications. A 0.1 mM solution of DPPH was prepared by dissolving DPPH in methanol and kept in the dark to prevent degradation. Different concentrations of the extract (e.g., 20–100 µg/mL) were prepared in methanol. Ascorbic acid was used as the reference standard. An aliquot of 1.0 mL of the extract solution was mixed with 1.0 mL of the DPPH solution. A control solution containing DPPH and methanol without the extract was prepared simultaneously. The reaction mixtures were vortexed and incubated in the dark at room temperature for 30 minutes to allow the reaction to occur. After incubation, the decrease in absorbance was measured at 517 nm using a UV–Visible spectrophotometer against a methanol blank. The percentage DPPH radical scavenging activity was calculated using the following equation:

$$\%\, DPPH\ scavenging\ potential = \frac{[(A_{control} - A_{sample}}{A_{control}}\ x\ 100$$

Inhibition of Lipid Peroxidation by Malondialdehyde (MDA) Assay (TBARS Method): The inhibitory capacity of the extract on lipid peroxidation was determined colorimetrically using the thiobarbituric acid reactive substances (TBARS) method as described by Tan et al. (2014) with slight modifications. A lipid-rich medium (such as egg yolk homogenate) was prepared by homogenizing fresh egg yolk in phosphate buffer (0.1 M, pH 7.4) to obtain a 10% (v/v) homogenate. The homogenate served as a source of polyunsaturated fatty acids for lipid peroxidation. Reaction mixtures were prepared by adding 0.5 mL of the egg yolk homogenate to 0.1 mL of the extract at various concentrations (e.g., 20–100 µg/mL). Lipid peroxidation was initiated by adding 0.05 mL of 0.07 M ferrous sulfate ($FeSO_4$). The volume of the reaction mixture was adjusted to 1.5 mL with phosphate buffer. A control containing all reagents except the extract was prepared simultaneously. The reaction mixtures were incubated at 37 °C for 30 minutes. After incubation, 1.5 mL of 20% trichloroacetic acid (TCA) and 1.5 mL of 0.67% thiobarbituric acid (TBA) were added to each tube. The mixtures were vortexed and heated in a boiling water bath at 95 °C for 30 minutes to allow the formation of a pink chromogen (MDA–TBA complex). The tubes were cooled to room temperature and centrifuged at 3000 rpm for 10 minutes to remove precipitated proteins. The absorbance of the supernatant was measured at 532 nm using a UV–Visible spectrophotometer against a reagent blank. The percentage inhibition of lipid peroxidation was calculated using the formula:

$$\%\, Inhibition\ of\ lipid\ peroxidation = \frac{[(A_{control} - A_{sample}}{A_{control}}\ x\ 100$$

Statistical Analysis

All values will be reported as the mean ± SEM (standard error mean). Duncan post hoc test was applied to compare values, as appropriate, using SPSS v 22.0 software. Values was considered significant at $p < 0.05$.

RESULT AND DISCUSSION

Antioxidant Activity & IC_{50} Values and Alkaloid content

The alkaloid fraction exhibited a dose-dependent increase in radical scavenging activity against hydroxyl and nitric oxide radicals as shown in table 1. At 320 µg/mL, the highest inhibitory effects were observed (68.50% and 79.60%, respectively), indicating a significant free radical neutralization potential. The fraction demonstrated progressive antioxidant activity, achieving maximum DPPH inhibition of 79.10% and lipid peroxidation inhibition of 86.90% at 320 µg/mL. The strong inhibition of lipid peroxidation reveals its potential to protect cellular membranes from oxidative damage, a property linked to phenolic and alkaloid constituents. The IC_{50} values indicate that the alkaloid fraction is effective but less potent than ascorbic acid, a standard antioxidant (see table 2). DPPH and nitric oxide radical IC_{50} values (92.70 µg/mL and 102.50 µg/mL) reflect strong scavenging capacity, whereas a higher IC_{50} for hydroxyl radicals (382.90 µg/mL) suggests differential affinity for distinct reactive species. The total alkaloids content of the fraction is 28.46%

Table 1: Percentage Inhibition of Alkaloid Fractions (N. laevis)

Concentration (µg/mL)	Hydroxyl Radical (%)	Nitric Oxide Radical (%)	**DPPH (%)**	**Lipid Peroxidation (%)**

20	26.40 ± 2.14	38.60 ± 1.15	45.20 ± 1.42	56.80 ± 1.90
40	37.00 ± 0.90	46.50 ± 2.60	48.90 ± 0.80	61.40 ± 0.78
80	48.20 ± 3.40	51.40 ± 1.70	62.10 ± 1.20	75.00 ± 1.26
160	57.40 ± 2.30	67.80 ± 0.85	74.20 ± 2.05	82.50 ± 3.05
320	68.50 ± 3.10	79.60 ± 0.90	79.10 ± 3.40	86.90 ± 2.60

Table 2: IC_{50} of N. laevis Scavenging Activity & Control (Ascorbic Acid)

Assay	***N. laevis* (µg/mL)**	**Control (µg/mL)**
Hydroxyl Radical	382.90 ± 4.20	124.20 ± 2.05
Nitric Oxide Radical	102.50 ± 3.10	86.10 ± 1.80
DPPH	92.70 ± 1.50	63.40 ± 2.80
Lipid Peroxidation	196.10 ± 4.10	112.60 ± 1.90

Antimicrobial Susceptibility Test

The alkaloid fraction showed dose-dependent antibacterial activity. *S. aureus* was most susceptible, with a maximum zone of 14.90 mm at 400 mg/mL (displayed in table 3). Gram-negative bacteria exhibited lower sensitivity, reflecting the general resistance of Gram-negative organisms to plant alkaloids due to their outer membrane barrier and standard antibiotics displayed larger zones.

Table 3: Zone of Inhibition (mm) against selected bacterial isolates

Concentration (mg/mL)	***S. aureus***	***S. typhi***	***P. aeruginosa***	***E. coli***
50	11.20 ± 0.60	7.40 ± 0.30	6.30 ± 0.52	6.50 ± 0.40
100	12.80 ± 0.70	9.11 ± 0.58	7.14 ± 0.28	7.20 ± 0.50
200	13.70 ± 0.50	10.00 ± 0.15	9.18 ± 0.35	8.40 ± 0.10
400	14.90 ± 1.05	11.80 ± 0.62	10.50 ± 0.60	10.70 ± 0.40
Cipro (250 µg/mL)	24.20 ± 1.50	18.50 ± 0.78	16.40 ± 2.10	19.80 ± 1.20
Ampx (30 µg/mL)	22.60 ± 2.40	21.40 ± 1.05	17.10 ± 3.08	18.70 ± 2.10

3.2.1. Minimum Inhibitory Concentration and Minimum bactericidal concentration Test

The MIC results indicate that the alkaloid fraction effectively inhibited the growth of *S. aureus*, *P. aeruginosa*, and *E. coli* at concentrations ≥50 mg/mL, while *S. typhi* showed inhibition at ≥100 mg/mL, suggesting slightly lower susceptibility. Growth observed at lower concentrations (≤25 mg/mL) confirms reduced efficacy at these levels as shown in table 4. The MBC data show that complete bactericidal activity occurred at 50 mg/mL for all tested organisms (see table 5). This indicates that the extract exhibits bacteriostatic effects at lower concentrations and bactericidal effects at higher concentrations, with relatively consistent killing activity across both Gram-positive and Gram-negative bacteria.

Table 4: MIC & MBC alkaloids fraction of *N laevis*

Test	**Organism**	**400**	**200**	**100**	**50**	**25**	**12.5**	**6.25**	**MIC value (**mg/mL)
MIC	S. aureus	–	–	–	–	–	+	+	25
	S. typhi	–	–	–	–	+	+	+	50
	P. aeruginosa	–	–	–	–	–	+	+	25
	E. coli	–	–	–	–	–	+	+	25

									MBC value (mg/mL)
MBC	S. aureus	–	–	–	–	+	+	+	50
	S. typhi	–	–	–	–	+	+	+	50
	P. aeruginosa	–	–	–	–	+	+	+	50
	E. coli	–	–	–	–	+	+	+	50

Discussion

Natural products remain a major source of bioactive compounds, and many modern pharmaceuticals have evolved from traditional herbal medicine (Marrelli, 2021). In this study, the alkaloid fraction of Newbouldia laevis leaves showed notable antioxidant and antibacterial activities, supporting its longstanding use in ethnomedicine. Antioxidant evaluation showed a clear concentration-dependent radical scavenging effect across hydroxyl, nitric oxide, DPPH, and lipid peroxidation assays. At the highest tested concentration (320 µg/mL), the fraction inhibited DPPH radicals and lipid peroxidation by 79.10% and 86.90%, respectively, indicating strong free-radical neutralizing capacity. These findings are consistent with previous reports that ethanolic leaf extracts of N. laevis exhibit potent dose-dependent scavenging activity, revealing the contribution of plant secondary metabolites to redox balance (Habu and Ibeh, 2015; Tsado et al., 2016)

The IC_{50} values further confirmed the antioxidant potential of the fraction, with inhibitory concentrations of 92.70 µg/mL for DPPH and 102.50 µg/mL for nitric oxide radicals, while lipid peroxidation was inhibited at 196.10 µg/mL. Although these values were higher than those of the reference antioxidant ascorbic acid, they still indicate substantial activity. The ability to inhibit lipid peroxidation is particularly important because it suggests protection against oxidative damage to cellular membranes, a key factor in the prevention and management of chronic diseases associated with oxidative stress (Bursal and Köksal, 2011' James et al., 2017; Leyane et al., 2022). This activity is likely linked to the presence of alkaloids alongside other phytochemicals such as phenolics and flavonoids, which may act synergistically to neutralize reactive oxygen and nitrogen species.

The antimicrobial findings further demonstrated that the alkaloid fraction possesses broad-spectrum activity against both Gram-positive and Gram-negative bacteria. Staphylococcus aureus was the most susceptible organism, exhibiting a zone of inhibition of 14.90 mm at 400 mg/mL. This observation aligns with earlier reports that *N. laevis* extracts tend to be more effective against Gram-positive bacteria (Akande et al., 2020). Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) results showed inhibition of S. aureus at 12.5 mg/mL, while other tested pathogens required 25 mg/mL, with bactericidal activity observed at 50 mg/mL. These findings are consistent with earlier studies reporting MIC values within a similar range for clinical isolates treated with *N. laevis* leaf extracts (Suleiman et al., 2023; Mba and Udeozo, 2025).

The antimicrobial mechanism of the alkaloid fraction is likely multifactorial. Alkaloids are known to disrupt bacterial cell membranes, bind to cellular proteins, and interfere with nucleic acid synthesis, thereby reducing microbial viability. In addition, the extraction solvent and method strongly influence the yield and diversity of bioactive compounds. Alkaloid-rich fractions obtained using ethanol or methanol often retain other secondary metabolites such as tannins, flavonoids, and saponins, which may act synergistically to enhance both antioxidant and antibacterial effects.

The results from this study support the dual pharmacological role of N. laevis in traditional medicine as both a free-radical scavenger and an antimicrobial agent. The antioxidant potency of the alkaloid fraction suggests potential therapeutic relevance in oxidative stress-related disorders, while its broad-spectrum antibacterial activity highlights its usefulness against pathogenic microorganisms. The significant bioactivity of the alkaloid fraction highlights its promise as a candidate for the development of plant-based therapeutics.

CONCLUSION

The alkaloid fraction of Newbouldia laevis revealed substantial antioxidant and antibacterial potential, reinforcing its traditional medicinal applications. The concentration-dependent radical scavenging and microbial inhibition, together with MIC and MBC data, indicate a clear pharmacological effect.

Competing interests
The authors declare that they have no competing interests

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Authors' contributions
Conceptualization: AO. Data curation: AO, NO, IEN. Investigation: AO, NO, IEN, CCU Methodology: AO, NO, IEN, CCU, RCJ. Validation: AO, NO, UE. Visualization: AO. Writing – original draft: AO, RCJ. Writing – review and editing: AO, UE, CCU, IEN. All authors read and approved the final manuscript.

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REFERENCES

Abdallah, E. M., Alhatlani, B. Y., de Paula Menezes, R., & Martins, C. H. G. (2023). Back to Nature: Medicinal plants as promising sources for antibacterial drugs in the post-antibiotic era. *Plants*, *12*(17), 3077.

Abookleesh, F. L., Al-Anzi, B. S., & Ullah, A. (2022). Potential antiviral action of alkaloids. *Molecules*, *27*(3), 903.

Akande, E. B., Oladejo, B. O., Oladunmoye, M. K., & Abodunrin, T. F. (2020). Antibacterial effects of *Newbouldia laevis* {P. BEAUV} on the bacteria isolated from the blood of Hepatitis C virus positive individuals. *Asian Plant Research Journal, 4*(1), 26–34.

Akerele, J. O., Ayinde, B. A., & Ngiagah, J. (2011). Phytochemical and antibacterial evaluations of the stem bark of Newbouldia laevis against isolates from infected wounds and eyes. *Tropical Journal of Pharmaceutical Research*, *10*(2).

Alisi, C. S., & Onyeze, G. O. C. (2008). Nitric oxide scavenging ability of ethyl acetate fraction of methanolic leaf extracts of Chromolaena odorata (Linn.). *African Journal of Biochemistry Research*, *2*(7), 145-150.

Arip, M., Selvaraja, M., Tan, L. F., Leong, M. Y., Tan, P. L., Yap, V. L., ... & Jubair, N. (2022). Review on plant-based management in combating antimicrobial resistance-mechanistic perspective. *Frontiers in Pharmacology*, *13*, 879495.

Brand-Williams, W., Cuvelier, M. E., & Berset, C. L. W. T. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT-Food science and Technology*, *28*(1), 25-30.

Bursal, E., & Köksal, E. (2011). Evaluation of reducing power and radical scavenging activities of water and ethanol extracts from sumac (Rhus coriaria L.). *Food Research International*, *44*(7), 2217-2221.

Chukwuma, G. E., & Nwachukwu, N. C. (2016). Phytochemical and antimicrobial activities of *Newbouldia laevis*' leaves on isolates from wound infections. *Scientia Africana, 15*(1), 78–86.

Dantas, R. F., Evangelista, T. C. S., Neves, B. J., Senger, M. R., Andrade, C. H., Ferreira, S. B., & Silva-Junior, F. P. (2019). Dealing with frequent hitters in drug discovery: a multidisciplinary view on the issue of filtering compounds on biological screenings. *Expert Opinion on Drug Discovery*, *14*(12), 1269-1282.

Flieger, J., Flieger, W., Baj, J., & Maciejewski, R. (2021). Antioxidants: Classification, natural sources, activity/capacity measurements, and usefulness for the synthesis of nanoparticles. *Materials*, *14*(15), 4135.

Habu, J. B., & Ibeh, B. O. (2015). In vitro antioxidant capacity and free radical scavenging evaluation of active metabolite constituents of *Newbouldia laevis* ethanolic leaf extract. *Biological Research, 48*, 16.

James, S. A., Sunday, A., Jonah, A., Ojonugwa, A. P., & Victoria, A. O. (2017). Phytochemical screening, mineral content analysis and assessment of antibacterial activity of methanol extract of Newbouldia laevis leaf. *Saudi J Pathol Microbiol*, *2*(6), 192-6.

Kanu, A. M., Kalu, J. E., & Kalu, T. (2018). In vitro evaluation of ethanolic and aqueous crude extracts of Newbouldia laevis leaves on bacterial isolates from ear infections. *Int J Pharmacol Phytochem Ethnomed*, *9*, 18-23.

Kuete, V., Eyong, K. O., Folefoc, G. N., Beng, V. P., Hussain, H., Krohn, K., & Nkengfack, A. E. (2007). Antimicrobial activity of the methanolic extract and of the chemical constituents isolated from Newbouldia laevis. *Die Pharmazie-An International Journal of Pharmaceutical Sciences*, *62*(7), 552-556.

Leyane, T. S., Jere, S. W., & Houreld, N. N. (2022). Oxidative stress in ageing and chronic degenerative pathologies: molecular mechanisms involved in counteracting oxidative stress and chronic inflammation. *International journal of molecular sciences*, *23*(13), 7273.

Marrelli, M. (2021). Medicinal plants. *Plants*, *10*(7), 1355.

Mba, A. N., & Udeozo, I. P. (2025). Comparative study of antimicrobial susceptibility and phytoconstituent analysis of *Newbouldia laevis* root and stem barks. *Anachem Journal, 16*(1), 69–78.

Oke, O. O., Adeoye, A. S., & Aderounmu, A. F. (2020). Phytochemical analyses of selected forest genetic resources for ethno-medicinal treatment of malaria/fever in Iseyin local government area of Oyo state Nigeria. *KIU J Soc Sci*, *6*, 233-240.

Peter, O., Ekene, O., Chiaguguom, I., Grace, F., Daniel, N., Ngozi, A., & Israel, O. (2022). Phytochemical screening, acute toxicity and analgesic activity of extracts from Newbouldia laevis in laboratory animals. *Path of Science*, *8*(7), 3001-3010.

Porras, G., Chassagne, F., Lyles, J. T., Marquez, L., Dettweiler, M., Salam, A. M., ... & Quave, C. L. (2020). Ethnobotany and the role of plant natural products in antibiotic drug discovery. *Chemical reviews*, *121*(6), 3495-3560.

Prabuseenivasan, S., Jayakumar, M., & Ignacimuthu, S. (2006). In vitro antibacterial activity of some plant essential oils. *BMC complementary and alternative medicine*, *6*, 1-8.

Ramabulana, T. (2016). *UPLC-MS based metabolomics investigation on the effects of gamma radiation on nutraceutical plants*. University of Johannesburg (South Africa).

Sharma, S., Pathak, S. C., & Kumar, B. (2020). Phytochemical profile of seeds of Guizotia abyssinica (L. f.) Cass (Niger or Ramtil). *IOSR J. Pharm. Biol. Sci.*, *15*(5), 14-22.

Sibri, J. F., Akakpo-Akue, J., Vanié, S. C., Kple, T. K. M., Soro, M. B., & Okou, O. C. (2023). Phytochemical Evaluation and Determination of the Content of Some Natural Antioxidants (Polyphenols and Flavonoids) from Ficus Capensis, Newbouldia laevis and Carpolobia lutea. *Asian Journal of Biology*, *19*(4), 29-37.

Sies, H., & Jones, D. P. (2020). Reactive oxygen species (ROS) as pleiotropic physiological signalling agents. *Nature reviews Molecular cell biology*, *21*(7), 363-383.

Sies, H., Belousov, V. V., Chandel, N. S., Davies, M. J., Jones, D. P., Mann, G. E., ... & Winterbourn, C. (2022). Defining roles of specific reactive oxygen species (ROS) in cell biology and physiology. *Nature reviews Molecular cell biology*, *23*(7), 499-515.

Srinivasan, R., Mathivanan, K., Govindarajan, R. K., Uthaya Chandirika, J., & Govindasamy, C. (2022). Extracellular synthesis of silver nanoparticles by bioluminescent bacteria: characterization and evaluation of its antibacterial and antioxidant properties. *International Nano Letters*, 1-9.

Suleiman, A., Bello, A. B., & Idris, A. D. (2023). Phytochemistry and antibacterial assessment of ethyl acetate leaf extract of *Newbouldia laevis*. *UMYU Journal of Microbiology Research (UJMR), 8*(1), 39–45.

Tan, C., Xue, J., Abbas, S., Feng, B., Zhang, X., & Xia, S. (2014). Liposome as a delivery system for carotenoids: Comparative antioxidant activity of carotenoids as measured by ferric reducing antioxidant power, DPPH assay and lipid peroxidation. *Journal of agricultural and food chemistry*, *62*(28), 6726-6735.

Usman, H., & Osuji, J. C. (2007). Phytochemical and in vitro antimicrobial assay of the leaf extract of Newbouldia laevis. *African Journal of Traditional, Complementary and Alternative Medicines*, *4*(4), 476-480.

Yan, Y., Li, X., Zhang, C., Lv, L., Gao, B., & Li, M. (2021). Research progress on antibacterial activities and mechanisms of natural alkaloids: A review. *Antibiotics*, *10*(3), 318.