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CHEMICAL STUDY AND ANTIMICROBIAL ACTIVITIES OF THE AERIAL PARTS OF *LAGGERA PTERODONTA*

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ABSTRACT

Chemical investigation of the crude methanolic extract of the aerial parts of *Laggera pterodonta* resulted in the isolation of five known compounds namely lupeol (1), stigmasterol (2), stigmasterol glycoside (3), Chrysosplenetin (4) and Artemitin (5). The structures of these compounds were established by using various spectroscopic methods including 1D NMR (1H NMR and 13C NMR) and 2D NMR (COSY, HMQC and HMBC) in conjunction with mass spectrometry and by the comparison with literature data. Flavonoids, particularly Flavonols derivatives and polymethoxylated flavones isolated from *Laggera pterodonta* and others species of genus Laggera appear to be useful as chemotaxonomic markers in Laggera. The crude extract was evaluated for its antibacterial activity against six strains and antifungal activity against six yeasts using the MHA and SDB methods. The results showed that the extract exhibited moderate antibacterial activity against Staphylococcus aureus and Shigella flexneri with a minimum inhibitory concentration (MIC) of 250 µg/mL, significant antifungal activity against Candida albicans with MIC of 62.5 µg/mL and moderate activity against Candida tropicalis with MIC of 250 µg/mL.

I. Introduction

Natural products have historically played a crucial role in drug discovery, particularly as sources of antimicrobial agents. In recent decades, the rapid emergence of antimicrobial resistance among pathogenic microorganisms has become a major global health concern, thereby increasing the need for new and effective therapeutic agents (World Health Organization, 2014). In this context, medicinal plants remain an important reservoir of structurally diverse bioactive compounds with potential pharmaceutical applications (Newman & Cragg, 2016).

The family Asteraceae is one of the largest families of flowering plants and is well known for its chemical diversity and biological activities. Numerous species within this family produce secondary metabolites such as flavonoids, terpenoids, and phenolic compounds, which are associated with antimicrobial, anti-inflammatory, and antioxidant properties (Bessada et al., 2015). Among these, the genus Laggera comprises several species distributed in tropical and subtropical regions, where they are widely used in traditional medicine for the treatment of infections, fever, and inflammatory disorders (Li et al., 2021).

Laggera pterodonta (DC.) Benth. is an aromatic herb commonly used in traditional medicine in Africa and Asia. Previous phytochemical investigations of this species have revealed the presence of various secondary metabolites, including polymethoxylated flavones, flavonols, sesquiterpenes, and essential oils (Xie et al., 2021; Yang et al., 2007). These compounds are known to contribute to a wide range of biological activities. Indeed, extracts and isolated constituents of *L. pterodonta* have been reported to exhibit anti-inflammatory, antiviral, antioxidant, and antimicrobial effects (Pham et al., 2026; Yang et al., 2007).

Flavonoids, which represent a major class of compounds found in Laggera species, have attracted considerable attention due to their antimicrobial properties. Their mechanisms of action include disruption of microbial cell membranes, inhibition of nucleic acid synthesis, and interference with metabolic pathways (Cushnie & Lamb, 2005). Moreover, structural features such as hydroxylation and methoxylation patterns significantly influence their biological activity (Cushnie & Lamb, 2005).

Despite the growing body of literature on the phytochemistry and pharmacology of *Laggera pterodonta*, the antimicrobial activity of its crude extracts and chemical constituents remains insufficiently documented, particularly against clinically relevant bacterial and fungal strains. Therefore, the present study aims to investigate the chemical composition and antimicrobial activities of the aerial parts of *Laggera pterodonta*. The study focuses on the isolation and characterization of secondary metabolites and the evaluation of the antibacterial and antifungal activities of the crude methanolic extract of the aerial parts using the broth microdilution method.

II. Materials and Methods

2.1 Plant Material

The aerial parts of *Laggera pterodonta* was harvested at Babadjou , west region of Cameroon. It was identified by Mr NGANSOP Eric, botanist at the National Herbarium in Yaoundé, where a voucher specimen (ref. 48450/HNC) was deposited.

2.2 Extraction and isolation of compounds

2.5 Kg of powder of the aerial parts of *Laggera pterodonta* species was obtained after cutting, drying and grinding. This resulting powder was extracted by maceration with MeOH at room temperature. After concentration in a rotary evaporator, 80 g of crude extract was obtained**.** A mass of 60 g of the extract was fixed to 86.03 g of silica gel (0.63-200 mm) in a chromatographic column and subjected to gradient elution with the solvent hexane, a mixture of hexane/ethyl acetate gradients, 100 % ethyl acetate and finally ethyl acetate/Methanol system of increasing polarity. A total of 510 fractions of 200 ml each were collected and then regrouped into 9 Fractions indexed from F1 to F12 based on analyses made on the TLC profiles.

Fraction F2 (10.0 g) was subjected to CC over silica gel, eluted with n-hex/EtOAc mixtures (95/5) and yielded compound 1 LPC3 (lupeol, 1,02 mg, white powder). Fraction F3 (10.0 g) was subjected to CC over silica gel eluted with n-hex/EtOAc mixture of polarity (90/10) and yielded compound 2 LPC4 (stigmasterol, 0,42 mg, white flakes). F6 (10.0 g) was subjected to CC over silica gel eluted with n-hex/EtOAc mixture of polarity (75/25) and yielded compound 5 LPC7 (Artemitin, 2.27 mg, yellow powder) and compound 4 LPC8 (Chrysosplenetin, 2.89 mg, yellow powder). F9 (10.0 g) was subjected to CC over silica gel, eluted with n-hex/EtOAc mixture of polarity (50/50) and yielded compound 3 LPC11 (stigmasterol glucoside, 1,43 mg, white powder).

2.3 Apparatus.

2.3.1. General

The following instruments and materials were used in this study:

An electronic balance (Sartorius TE 612) was employed for weighing the masses of extracts, silica gel, and isolated compounds. Extract concentration was carried out using a rotary evaporator (JANKE & KUNKEL, IKA-WERK, model RV05, No. 70799). Drying of extracts was performed in an oven (AGGNCINUX Z.I., No. 000526, Ref. 5730).

Thin-layer chromatography (TLC) analyses were conducted under a UV lamp (CAMAG, model TL-9001) operating at wavelengths of 254 and 350 nm. Silica gel 60 (Merck, 70–230 mesh and 230–400 mesh) was used for column chromatography. Precoated silica gel plates (Merck, 20 × 20 cm, thickness 0.2 mm, silica gel 60 F254) were used for TLC analysis. A cylindrical chromatographic chamber was used for plate development, and spots were visualized using 20% sulfuric acid.

Mass spectra (ESI and HR-ESI) were recorded on a microTOF mass spectrometer (Bruker), while EI and HR-EI mass spectra were obtained using a JEOL MS 600-I mass spectrometer.

^{1}H and ^{13}C NMR spectra were recorded on Varian Unity 300 (300 and 145 MHz), Varian Inova 500 (500 and 876 MHz), and Bruker DRX (400 MHz) spectrometers.

Büchi round-bottom flasks (500 mL and 1000 mL) were used for solvent evaporation during the concentration of crude extracts and fractions. A spectrophotometer was used to calibrate spore suspensions. Test tubes were used to contain the suspensions, while microplates and Petri dishes were used for microbiological assays.

Graduated cylinders (Silberbrand, 100, 500, and 1000 mL) were used for measuring solvent volumes. A chromatographic column was used for compound separation. Pasteur pipettes were used for fraction collection, and capillary tubes were used for spotting samples onto TLC plates.

The solvents used included water, methanol, ethyl acetate, dichloromethane, acetone, and hexane.

2.3.2 Biological Materials

The biological material used in this study consisted of the following pathogenic microorganisms:

Bacterial strains included Acinetobacter baumannii (9667), Escherichia coli (25922), Klebsiella pneumoniae (41817), Pseudomonas aeruginosa (48982), Staphylococcus aureus (46003), and Shigella flexneri (518).

Fungal strains included Candida albicans (14516), Candida auris (52713), Candida tropicalis (320B), Candida parapsilosis (031S), Candida glabrata (100), and Candida krusei (1415).

2.3.2. Biological assay

- **Antibacterial assay**

The antibacterial activity of the plant extract and isolated compounds was evaluated by determining the minimum inhibitory concentration (MIC) using the broth microdilution method in accordance with CLSI guidelines (CLSI, 2008). Bacterial inocula of Acinetobacter baumannii, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus aureus, and Shigella flexneri were prepared and adjusted to 0.5 McFarland standard, corresponding to approximately 1.5×10^6 CFU/mL.

Assays were performed in sterile 96-well microplates. Briefly, 196 µL of Mueller–Hinton broth (MHB) were added to wells in row A (columns 1–12), while 100 µL were dispensed into rows B to H. Then, 4 µL of sterile plant extract solution (100 mg/mL) were introduced into row A, followed by two-fold serial dilutions down to row F. Subsequently, 100 µL of bacterial suspension were added to all wells except row H (sterility control). Column 11 served as the negative control (medium plus inoculum), whereas column 12 served as the positive control containing ciprofloxacin. Final bacterial inoculum concentration was approximately 5×10^5 CFU/mL. Plates were incubated at 37°C for 24 h, after which 20 µL of resazurin solution (0.15 mg/mL) were added and incubated for an additional 30 min. All experiments were performed in triplicate and repeated twice.

- **Antifungal Assay**

The antifungal activity against Candida albicans, Candida auris, Candida tropicalis, Candida parapsilosis, Candida glabrata, and Candida krusei was assessed using the same broth microdilution method following CLSI recommendations (CLSI, 2008). Fungal inocula were prepared in sterile physiological saline and adjusted to obtain a final concentration of approximately 1×10^4 CFU/mL.

The assay procedure was identical to that described for antibacterial testing. Briefly, Mueller–Hinton broth (MHB) was distributed into 96-well microplates, and plant extract solutions (100 mg/mL) were serially diluted two-fold. Then, 100 µL of fungal suspension were added to each well, except for sterility controls. Column 11 was used as the negative control, while column 12 contained amphotericin B as the positive control. Plates were incubated at 37°C for 24 h, followed by the addition of 20 µL of resazurin solution (0.15 mg/mL) and further incubation for 30 min. Each test was carried out in triplicate and repeated twice.

III. Results and Discussion

3.1 Identification of Compounds.

The crude methanolic extract of the aerial parts of *Laggera pterodonta* was subjected to repeated column chromatography (CC) on silica gel and five known compounds were isolated: One terpenoid, lupeol (1) (Kuljanabhagavad et al., 2009), two sterols, stigmasterol (2) (Liu B et al.,2010) and stigmasterol glycoside (3) (Zhao Y et al., 1997), two flavones Chrysosplenetin (4) (Tarik A et al.,2016) and Artemitin, (5) (Tarik A et al.,2016)

Compound LPC8 was isolated using a Hexane/Ethyl acetate (Hex/EtOAc, 25%) solvent system as a yellow powder, soluble in chloroform. It gave a positive Shinoda test, producing a red coloration characteristic of flavonoids (Ahmed et al., 2016).

The positive-mode ESI mass spectrum exhibited a pseudo molecular ion peak $[M + H]^+$ at m/z 375.8, corresponding to a molecular weight of 374 g/mol and the molecular formula $C_{19}H_{1}8O_{8}$, indicating 11 degrees of unsaturation.

The ^1H NMR (table1) spectrum revealed a characteristic singlet at δH 12.63, attributable to a chelated hydroxyl proton at position C-5, typical of flavonoids (Ahmed et al., 2016). In the aromatic region, three signals integrating for one proton each were observed at δH 7.07 (1H, d, J = 8.5 Hz), 7.69 (1H, dd, J = 2.2, 8.5 Hz), and 7.73 (1H, d, J = 2.0 Hz), corresponding to an ABX spin system of ring B.

A singlet at δH 6.53 (1H, s) was assigned to a pentasubstituted aromatic proton (H-8) of ring A. Additionally, four singlets integrating for three protons each at δH 4.00, 3.99, 3.95, and 3.89 were attributed to methoxy groups. Another singlet at δH 6.00 (1H, s) was assigned to a hydroxyl proton. The absence of signals corresponding to H-2 and H-3 suggested a flavone-type skeleton.

The ^{13}C NMR (table1) spectrum (125 MHz, $CDCl_3$) confirmed these observations, displaying 19 carbon signals. These included 10 quaternary carbons, among which a carbonyl carbon at δC 178.9 (C-4) and an oxygenated sp^2 carbon at δC 138.7 (C-3), characteristic of flavones (Ahmed et al., 2016). Four methine carbons were observed at δC 106.6, 114.6, 122.5, and 115.7, along with four methoxy carbons at δC 60.92, 60.20, 56.36, and 56.10. These data are consistent with polymethoxylated flavones reported in the literature (Ahmed et al., 2016).

Further structural elucidation was achieved using 2D NMR experiments. The COSY spectrum showed homonuclear correlations between the proton at δH 7.73 and those at δH 7.69 and 7.07, confirming the ABX spin system. The HSQC spectrum allowed direct proton–carbon assignments, showing correlations between δH 6.53/δC 90.4, δH 7.07/δC 114.6, δH 7.73/δC 122.5, and δH 7.69/δC 110.9.

The NOESY spectrum revealed spatial correlations, notably between methoxy protons (δH 3.98–4.01) and aromatic or hydroxyl protons, indicating their relative spatial proximity and orientation.

The HMBC spectrum provided key long-range correlations. Methoxy protons at δH 4.01, 3.98, 3.95, and 3.89 correlated with carbons at δC 146.4, 158.8, 132.2, and 138.7, respectively, indicating their attachment to these carbons. The signal at δC 138.7 was assigned to C-3 bearing a methoxy group (Iinuma et al., 1986).

Correlations between the proton at δH 6.53 and quaternary carbons at δC 106.6, 132.2, 152.7, and 158.8, combined with NOESY data, allowed its assignment to H-8, with methoxy groups positioned at C-6 and C-7 on ring A.

Additional HMBC correlations between aromatic protons at δH 7.69 and 7.73 with oxygenated carbons at δC 156.0 (C-2) and 148.4 supported their assignment to positions C-5′ and C-6′, confirming the ABX system. Furthermore, correlations involving the hydroxyl proton (δH 6.04) and carbons at δC 114.6, 146.4, and 148.4, together with NOESY data, allowed the placement of a methoxy group at C-3′ and a hydroxyl group at C-4′.

Based on the combined physicochemical and spectroscopic data and comparison with literature values, compound LPC8 was identified as Chrysosplenetin, previously reported and recently isolated from Chiliadenus montanus (Tarik et al., 2016).

3.2 Flavonoids as Chemotaxonomic Markers in the Genus Laggera

Phytochemical investigations of species belonging to the genus Laggera have consistently reported the occurrence of flavonoids, particularly flavonol derivatives and polymethoxylated flavones, which are considered important chemotaxonomic markers. In *Laggera pterodonta*, several flavonoids have been identified, including flavonols such as quercetin, tamarixetin, and patuletin, as well as their glycosides (e.g., quercetin-3-O-glycosides and kaempferol derivatives) (Liu et al., 2010; Lu et al., 2014). In addition, polymethoxylated flavones such as Chrysosplenetin, artemitin, and 3,5-dihydroxy-3′,4′,6,7-tetramethoxyflavone have been isolated from this species (Yang et al., 2007; Xie et al., 2021).

Further studies on other species such as *Laggera alata* and *Laggera crispata* have confirmed the presence of related flavonoids, including luteolin, apigenin, and several methoxylated flavone derivatives, reinforcing the chemical consistency within the genus (Lu et al., 2014; Xie et al., 2021). The recurrence of polymethoxylated flavones, particularly chrysosplenetin-type compounds, across Laggera species suggests the existence of conserved biosynthetic pathways within the genus (Wang et al., 2013). These compounds are relatively uncommon in higher plants but are characteristic of members of the family Asteraceae.

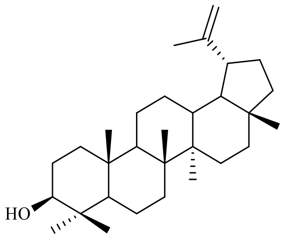
The chemotaxonomic significance of these metabolites has been highlighted in several studies, which demonstrate that flavonoids constitute one of the major classes of secondary metabolites in *Laggera pterodonta* and related species (Xie et al., 2021; Pham et al., 2026). Moreover, comprehensive investigations have reported a wide diversity of compounds, including numerous flavonoids, supporting the chemical richness and taxonomic relevance of this species (Pham et al., 2026).

Overall, the consistent occurrence of flavonol derivatives and polymethoxylated flavones supports their use as reliable chemotaxonomic markers for the genus Laggera, contributing to species differentiation and phylogenetic classification.

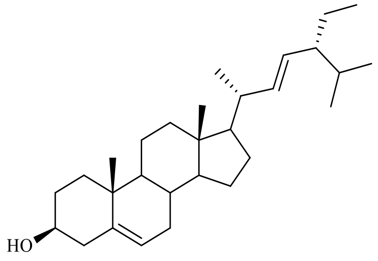
Table 1: Comparison of ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (125 MHz, $CDCl_3$) data of LPC8 with those reported for Chrysosplenetin (Ahmed et al., 2016).

Positions	LPC8		5,4′-dihydroxy-3,6,7,3′-tétrametoxyflavone	
	δH (m, J en Hz) ppm	δc (ppm)	δH (m, J en Hz)	δc (ppm)
2	/	156,0	/	156,0

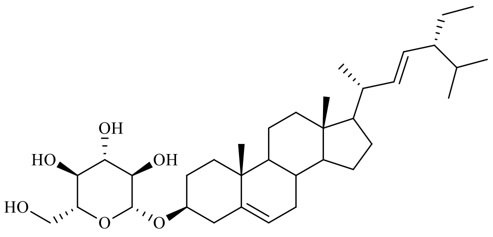
3		138,9		138,9
4	/	178,9	/	179,9
5	OH (12,63)	152,7	OH (12,5)	153,0
6		132,2	6,18 (d; 1,8)	132,3
7		158,8		158,9
8	6,53 (1H; d; J= 2,1)	90,4	6,55 (1H ; s)	92,4
9	/	152,7	/	152.5
10	/	106,6	/	109,3
1’	/	130,4	/	122,5
2’	7,69 (1H; d; J= 2,2)	110,9	7,67 (1H ;d; J= 2,0)	110,9
3’		146,4		146,4
4’	OH (6,04)	148,4	OH (6,05)	148,5
5’	7,07 (1H; d; J= 8,5)	115,8	6,99(1H ; d ; J=8,4)	115,7
6’	7,73 (1H; dd; J= 8.5; 2.2)	122,5	7,67(1H ; dd ;J=8.4,2.0)	122,9
OMe-6	4,00 (3H ;s)	60,9	4,00 (3H ;s)	60,1
OMe-7	3,99 (3H ;s)	60,2	3,96 (3H ;s)	56,3
OMe-3’	3,95 (3H ;s)	56,8	3,95 (3H ;s)	56,9
OMe-3	3,89 (3H ;s)	56,1	3,84 (3H ;s)	56,1



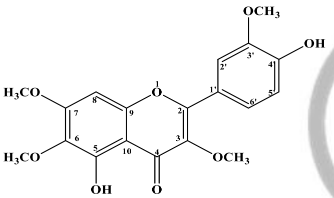
lupeol (1)



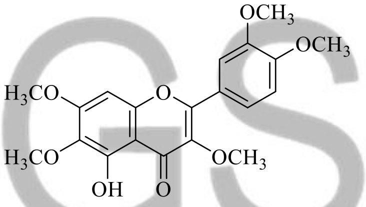
stigmasterol (2)



stigmasterol glycoside (3)



Chrysosplenetin (4)



Artemitin (5)

Figure 1: Structure of some isolated compounds

3.4 Evaluation of biological activities

The methanolic extract of the aerial parts of *Laggera pterodonta* was evaluated for antibacterial and antifungal activities using the broth microdilution method. The minimum inhibitory concentrations (MICs) obtained are summarized in Tables 2 and 3.

3.4.1 Evaluation of antibacterial activity

Two of the six bacterial strains tested were sensitive to the extract, namely Staphylococcus aureus and Shigella flexneri, with a minimum inhibitory concentration (MIC) of 250 µg/mL. According to the scale of Kuete et al. (2010), when the MIC ranges between 1 and 100 µg/mL, the extract exhibits good (significant) activity; when the MIC ranges between 100 and 500 µg/mL, the extract shows moderate activity; and when the MIC is ≥ 500 µg/mL, the extract exhibits weak activity. Our results indicate that the crude extract displays moderate antibacterial activity against these two strains (Kuete et al., 2010).

Table 2. Inhibition parameters of the crude extract and reference antibiotic against different bacterial strains

Concentration Minimale Inhibitrice (CMI en µg/ml)						
Extrait brut	*KP*	*PA*	*AB*	*EC*	*SA*	*SF*
EBLPC	/	/	/	/	250	250
Ciprofloxacin	0,031	0,125	>1	0,25	0,125	1,00

Legend: Minimum inhibitory concentration (MIC); AB = Acinetobacter baumannii (9667), EC = Escherichia coli (25922), KP = Klebsiella pneumoniae (41817), PA = Pseudomonas aeruginosa (48982), SA = Staphylococcus aureus (46003), SF = Shigella flexneri (518).
EBLPC: Crude extract of Laggera pterodonta; (/) inactive. Red color: significant activity; Blue color: moderate activity.

3.4.2 Evaluation of antifungal activity

The methanolic extract of the aerial parts of *Laggera pterodonta* showed significant activity against Candida albicans with an MIC of 62.5 µg/mL and moderate activity against Candida tropicalis with an MIC of 250 µg/mL (Kuete et al., 2010).

Table 3. Inhibition parameters of the crude extract and reference antifungal against different fungal strains

Concentration Minimale Inhibitrice (CMI en µg/ml)						
Extrait brut	*CA*	*CAR*	*CT*	*CP*	*CG*	*CK*
EBLPC	62,5	/	250	/	/	/
Amphotericin B	0,5	1,25	2,5	0,25	0,25	1,00

Legend: Minimum inhibitory concentration (MIC);
EBLPC: Crude extract of Laggera pterodonta; (/) inactive. Red color: significant activity; Blue color: moderate activity. CA = Candida albicans (14516), CAR = Candida auris (52713), CT = Candida tropicalis (320B), CP = Candida parapsilosis (031S), CG = Candida glabrata (100), CK = Candida krusei (1415).

3.4.3 Discussion on antimicrobial activities

The antimicrobial evaluation of the methanolic extract from the aerial parts of *Laggera pterodonta* revealed a selective but noteworthy activity against certain tested microorganisms. The antibacterial results indicated that the crude extract exhibited activity only against Staphylococcus aureus and Shigella flexneri, with a minimum inhibitory concentration (MIC) of 250 µg/mL, while no inhibition was observed against Acinetobacter baumannii, Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa.

According to the classification proposed by Kuete et al. (2010), the observed MIC values fall within the range of moderate activity (100–500 µg/mL). This moderate antibacterial effect may be attributed to the presence of bioactive secondary metabolites such as flavonoids, which are known to interfere with bacterial cell wall synthesis, membrane permeability, and enzymatic systems (Cushnie & Lamb, 2011; Daglia, 2012). The higher susceptibility of Staphylococcus aureus, a Gram-positive bacterium, compared to most Gram-negative strains, may be explained by the structural differences in their cell envelopes. Gram-negative bacteria possess an outer membrane rich in lipopolysaccharides, which acts as an effective permeability barrier limiting the penetration of antimicrobial compounds (Nikaido, 2003). However, the sensitivity of Shigella flexneri suggests that some constituents of the extract are capable of overcoming or disrupting this barrier.

Regarding antifungal activity, the extract demonstrated a more pronounced effect against Candida albicans (MIC = 62.5 µg/mL), corresponding to significant activity, and moderate activity against Candida tropicalis (MIC = 250 µg/mL) (Kuete et al., 2010). The absence of activity against other Candida species may reflect intrinsic resistance mechanisms such as efflux pumps, biofilm formation, or differences in membrane sterol composition (Perfect, 2017).

The relatively high sensitivity of Candida albicans could be associated with the presence of phenolic compounds, particularly flavonoids and polymethoxylated flavones, which have been widely reported to exert antifungal effects through multiple mechanisms, including disruption of membrane integrity, inhibition of ergosterol biosynthesis, and induction of oxidative stress (Cushnie & Lamb, 2011; Daglia, 2012). These findings are consistent with previous phytochemical studies on Laggera pterodonta, which reported a high content of flavonoids with recognized antimicrobial properties (Xie et al., 2021).

Overall, the results indicate that the crude extract of Laggera pterodonta exhibits moderate antibacterial activity and selective but significant antifungal activity. Although the activity remains lower than that of standard drugs such as ciprofloxacin and amphotericin B, the observed bioactivity supports the traditional use of this plant and highlights its potential as a source of antimicrobial agents. Further studies focusing on the isolation of active compounds and elucidation of their mechanisms of action are necessary.

IV. Conclusion

One terpenoid, lupeol (1), two sterols, stigmasterol (2) and stigmasterol glycoside (3) and two flavons Chrysosplenetin (4) and Artemitin, (5) were isolated from the areal parts of Laggera pterodonta. According to the previous works done on some species of genus Laggera and others species belonging to the Asteraceae family, we finally conclude that flavonol derivatives and polymethoxylated flavones appear to be useful as chemotaxonomic markers in Laggera. The methanolic extract of the aerial parts of this species was also tested to examine its antimicrobial potential. The extract exhibited moderate antibacterial activity against Staphylococcus aureus and Shigella flexneri, and significant antifungal activity against Candida albicans, with moderate effects on Candida tropicalis. These findings suggest a selective spectrum of activity, likely associated with the presence of bioactive secondary metabolites, particularly flavonoids and polymethoxylated flavones identified in this species.

Although the antimicrobial activity of the crude extract was lower than that of standard reference drugs, its effectiveness against clinically relevant pathogens supports its traditional medicinal use and indicates its potential as a source of novel antimicrobial compounds. The results also reinforce the chemotaxonomic importance of flavonoids in the genus Laggera.

Future work should focus on the isolation and characterization of the active constituents, as well as detailed investigations of their mechanisms of action and potential synergistic effects. Such studies could contribute to the development of new therapeutic agents to combat antimicrobial resistance.

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