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ANTI OXIDANT, ANTI MICROBIAL AND ANTI BACTERIAL ACTIVITIES FROM LEAF AND STEM OF PLECTRANTHUS AMBOINICUS – A REVIEW

Sandeep K. S.*[1], Aneesa K[2], Ayishath Raihana P[2], Fathimath Farzana C. S.[2], Hiba Nalupurappattil Sulaiman[2], Nafeesath Jamsheena B. M.[2]

[1]Lecturer, Department of Pharmacognosy, Malik Deenar College of Pharmacy Seethangoli, Kasaragod Kerala India.

[2]Student, Department of Pharmacognosy, Malik Deenar College of Pharmacy Seethangoli, Kasaragod Kerala India.

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***Corresponding Author: Sandeep K. S.**

Lecturer, Department of Pharmacognosy, Malik Deenar College of Pharmacy Seethangoli, Kasaragod Kerala India.

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ABSTRACT

Plectranthus amboinicus (Lour.) Spreng. is an important medicinal plant belonging to the Lamiaceae family.It is traditionally used for the treatment of cough, cold, sore throat, bronchitis, and other ailments.The plant possesses several pharmacological properties, particularly antioxidant and antimicrobial activities.This review focuses mainly on the antioxidant, antimicrobial, and antibacterial potential of its leaves and stems.Different solvent extracts have been investigated for their biological activities.Antioxidant activity was evaluated using DPPH, reducing power, nitric oxide scavenging, and total antioxidant assays. The extracts showed significant free-radical-scavenging and antioxidant activity.Phenolics, flavonoids, tannins, and terpenoids contribute considerably to this activity.Rosmarinic acid was identified as an important phenolic constituent in the stem extract.Leaf extracts also demonstrated antimicrobial and antibiofilm activity against bacterial pathogens.The antimicrobial activity varied with the developmental stage of the leaves.Antibacterial activity was reported against organisms including *Staphylococcus aureus* and MRSA.The activity may be associated with phenolic acids, flavonoids, terpenoids, and essential oils.Overall, *P. amboinicus* represents a promising natural source of bioactive compounds.Further studies are required to identify active constituents and establish their therapeutic potential.

INTRODUCTION

Plectranthus amboinicus (Lour.) Spreng., commonly known as Country Borage, Mexican Mint, or Spanish Thyme, is a medicinal herb belonging to the Lamiaceae family. Native to eastern and southern Africa, it is now widely distributed in tropical and subtropical regions.Traditionally, it has been used to treat cough, cold, sore throat, bronchitis, diarrhoea, and insect bites. The plant possesses antimicrobial, anti-inflammatory, antioxidant, antidiabetic, antihyperlipidemic, antitumor, and anticancer activities, which are mainly attributed to its rich phytochemical constituents such as terpenoids, alkaloids, flavonoids, phenols, tannins, glycosides, and sesquiterpenoids.[1]

Antioxidant Activity of *Plectranthus amboinicus* Leaves

In this study, the leaves of Plectranthus amboinicus (Lour.) Spreng were selected to evaluate their antioxidant potential. Fresh leaves were collected, shade-dried, and powdered before extraction. Two different solvents were used for extraction: ethanol and water (aqueous extract). These extracts were then analyzed through preliminary phytochemical screening and various antioxidant assays, including the DPPH radical scavenging assay, Nitric Oxide (NO) radical scavenging assay, Reducing Power Assay, and Total Phenolic Content estimation using the Folin–Ciocalteu method.[2]

The phytochemical screening revealed the presence of several bioactive compounds such as flavonoids, tannins, phenolic compounds, terpenoids, alkaloids, glycosides, proteins, and amino acids. These phytochemicals are well known for their antioxidant properties and contribute to protecting cells from oxidative stress caused by free radicals.[3]

The antioxidant assays demonstrated that both the ethanolic and aqueous leaf extracts possessed significant free radical scavenging activity. However, the ethanolic extract consistently exhibited stronger antioxidant activity than the aqueous extract. This enhanced activity is likely due to the higher extra2ction efficiency of ethanol for polyphenolic compounds, especially flavonoids and tannins, which are recognized as powerful natural antioxidants.[4]

The Total Phenolic Content estimation further supported these findings by showing that the ethanolic extract contained a higher concentration of phenolic compounds than the aqueous extract. Since phenolic compounds play a major role in neutralizing free radicals and preventing oxidative damage, their higher concentration explains the superior antioxidant activity of the ethanolic extract.

The study confirmed that Plectranthus amboinicus leaves are a rich source of natural antioxidants. The antioxidant activity is mainly attributed to the presence of polyphenolic compounds, particularly flavonoids and tannins. The findings suggest that Plectranthus amboinicus has promising potential as a natural antioxidant for pharmaceutical and nutraceutical applications. However, further research is recommended to isolate, identify, and characterize the specific active constituents responsible for its antioxidant effects and to evaluate their therapeutic potential in clinical applications.[5]

Antioxidant Activity of *Plectranthus amboinicus* Stems

In this study, the stem of *Plectranthus amboinicus* (Lour.) Spreng. was selected to evaluate its antioxidant potential. The stem was dried, powdered, and extracted using methanol. The methanolic stem extract was subjected to phytochemical analysis and evaluated for antioxidant activity using different in vitro assays, including the DPPH radical scavenging assay, reducing power assay, superoxide anion radical scavenging assay, and total antioxidant capacity assay.[6]

The phytochemical analysis revealed the presence of several bioactive compounds, particularly phenolic compounds, flavonoids, and condensed tannins. The stem extract contained 49.91 mg gallic acid equivalents (GAE)/g of total phenolics, 26.6 mg rutin equivalents (RE)/g of flavonoids, and 0.7 mg tannic acid equivalents (TAE)/g of condensed tannins[7]. HPLC analysis further identified phenolic compounds such as rosmarinic acid, caffeic acid, rutin, gallic acid, quercetin, and p-coumaric acid, with rosmarinic acid being the predominant phenolic constituent.[8]

The antioxidant assays demonstrated that the methanolic stem extract possessed significant free-radical-scavenging activity. The DPPH assay showed approximately 96% radical inhibition at a concentration of 180–200 ppm. The reducing power increased with increasing concentration, with absorbance values increasing from 0.085 ± 0.003 at 25 ppm to 0.347 ± 0.021 at 125 ppm[9]. The extract also showed concentration-dependent superoxide anion radical-scavenging activity, reaching approximately 61% inhibition at 250 ppm. The total antioxidant capacity of the extract was reported as 634.95 µM ascorbic acid equivalents/g extract.[10]

The antioxidant activity of the stem extract was associated with its phenolic and flavonoid constituents. In particular, rosmarinic acid was identified as the major phenolic compound and may contribute substantially to the antioxidant potential of the extract. Phenolic

compounds can donate hydrogen atoms or electrons to free radicals, thereby helping to neutralize reactive species and protect biological systems from oxidative damage.[11]

The study demonstrated that the stem of *Plectranthus amboinicus* is a promising source of natural antioxidant compounds. The methanolic stem extract exhibited strong DPPH radical-scavenging activity, appreciable reducing power, superoxide anion-scavenging activity, and total antioxidant capacity. The antioxidant potential was mainly associated with phenolic and flavonoid constituents, particularly rosmarinic acid. These findings suggest that the stem of *P. amboinicus* may have potential applications in pharmaceutical and nutraceutical preparations. Further studies are required to isolate and characterize the individual active constituents and establish their mechanisms of antioxidant action.[12]

Antimicrobial Activity of *Plectranthus amboinicus* Leaves

In this study,investigated the antimicrobial and antibiofilm potential of *Plectranthus amboinicus* L. and evaluated the influence of different stages of leaf development on its biological activity. *P. amboinicus* is recognized as a medicinal and aromatic plant containing bioactive compounds, particularly essential oils secreted by glandular trichomes present on the leaves. Since the production and composition of these phytochemicals may vary during leaf development, the study was undertaken to compare the biological activity of leaves at different developmental stages and to determine the stage showing the highest antimicrobial and antibiofilm potential.[13]

The leaves of *Plectranthus amboinicus* were selected as the plant material for the investigation. Leaves representing three developmental stages, namely lag phase, log phase, and stationary phase, were examined. These developmental stages were compared to determine their influence on the production of bioactive phytochemicals and their subsequent antimicrobial effects. Particular attention was given to the glandular and non-glandular trichomes present on the leaves, as glandular trichomes are important sites for the production and secretion of essential oils and other bioactive constituents.

For the experimental study, extracts prepared from leaves at the different developmental stages were evaluated against two important bacterial pathogens, *Pseudomonas aeruginosa* PAO1 and *Staphylococcus aureus* NCTC8325. The antimicrobial activity was assessed by determining the minimum inhibitory concentration (MIC) of the extracts. Their effects on biofilm formation and biofilm dispersal were also investigated. In addition, the study evaluated bacterial cell-surface hydrophobicity and motility, which are important factors associated with bacterial adhesion, colonization, and virulence. Cryo-scanning electron

microscopy (Cryo-SEM) was used to investigate the abundance and distribution of glandular and non-glandular trichomes during leaf development. Furthermore, gas chromatography–mass spectrometry (GC–MS) analysis was carried out to identify the phytochemical constituents present in the extracts and to compare their composition at different stages of leaf development.[14]

The results demonstrated that the antimicrobial and antibiofilm activities of *P. amboinicus* varied considerably according to the developmental stage of the leaves. The log-phase leaf extract showed the lowest minimum inhibitory concentration of 25 mg/mL, indicating comparatively stronger antimicrobial activity than extracts obtained from the other developmental stages. The log-phase extract also showed the highest biofilm inhibitory activity, producing approximately 66% inhibition against *P. aeruginosa* and 63% against *S. aureus*. In contrast, the stationary-phase extract showed the highest biofilm-dispersal activity against *P. aeruginosa*, reaching approximately 80%, while the log-phase extract produced approximately 59% biofilm dispersal against *S. aureus*. The extracts also reduced bacterial motility and cell-surface hydrophobicity, demonstrating their ability to interfere with important bacterial virulence-associated properties. GC–MS analysis revealed that thymol was a major phytochemical constituent, particularly in the log-phase and stationary-phase extracts, where it accounted for approximately 30.28% and 20.89%, respectively.

The study demonstrated that the developmental stage of *Plectranthus amboinicus* leaves significantly influences their antimicrobial and antibiofilm activity. Among the tested stages, the log-phase leaf extract exhibited particularly strong antimicrobial, antibiofilm, and anti-virulence effects, which may be associated with its phytochemical composition and higher abundance of compounds such as thymol. The findings suggest that *P. amboinicus* leaves may be a promising source of natural antimicrobial compounds and could have potential applications in pharmaceutical research. Further investigations are required to isolate the individual active constituents and establish their specific mechanisms of antimicrobial and antibiofilm action.[13]

Antimicrobial Activity of *Plectranthus amboinicus* stems

The antimicrobial activity of Plectranthus amboinicus stem extracts has been investigated across several studies, each highlighting its phytochemical richness and moderate bioactivity compared to leaf extracts. The plant, belonging to the Lamiaceae family, is traditionally valued for treating respiratory, digestive, and skin ailments. With the rise of antibiotic resistance, researchers have turned to medicinal plants like P. amboinicus to identify new

antimicrobial agents. While leaves are more commonly studied, stems also contain significant levels of phenolics, flavonoids, diterpenes, and steroids that contribute to antimicrobial properties.[15]

In terms of methodology, stem extracts were prepared using Soxhlet extraction with solvents such as methanol, ethanol, chloroform, and water. The antimicrobial activity was assessed using the agar well diffusion method, where inhibition zones against bacterial and fungal strains were measured. Test organisms included Gram-negative bacteria like Klebsiella pneumoniae and Shigella flexneri, Gram-positive bacteria such as Staphylococcus aureus and Bacillus cereus, and fungi including Candida albicans and Aspergillus species.

The part used in these studies was primarily the stem, which was found to contain compounds such as caffeic acid, rosmarinic acid, verbascoside, salvianolic acid, luteolin, and diterpenes. Quantitative analysis revealed that stem extracts had a total phenolic content of about 16.55 mg gallic acid equivalents per gram of extract, with flavonoids and diterpenes also present in measurable amounts.[16]

Results indicated that stem extracts exhibited moderate antimicrobial activity. Methanol stem extracts showed inhibition against several bacterial strains, though the activity was generally lower than that of leaf extracts. For example, leaves produced inhibition zones up to 35 mm against K. pneumoniae, while stems showed smaller but significant zones. Stem extracts were particularly noted for their phenolic and flavonoid content, which are responsible for antimicrobial effects.

Plectranthus amboinicus stem extracts demonstrate antimicrobial potential, though less pronounced than leaf extracts. Their activity is attributed to phenolic acids, flavonoids, and diterpenes, making stems a supplementary source of bioactive compounds. These findings suggest that stem extracts could be utilized alongside leaf extracts in developing plant-based antimicrobial formulations, contributing to the search for alternatives to conventional antibiotics.[17]

Antibacterial Activity of *Plectranthus amboinicus* leaves

The antibacterial potential of *P. amboinicus* has received considerable scientific attention. Studies have demonstrated that leaf extracts can inhibit the growth of several pathogenic bacteria. For example, acetone and ethyl acetate extracts of the leaves were reported to possess antibacterial activity and to cause disruption of bacterial cell walls and leakage of cellular components. These findings indicate that the bioactive compounds present in the leaves may interfere with bacterial cell integrity and contribute to their antibacterial effect.

Among the pharmacological properties reported for *P. amboinicus*, its antibacterial activity is of particular interest. Bacterial infections remain an important public-health concern, and the increasing emergence of antimicrobial-resistant microorganisms has encouraged the search for new antibacterial substances from natural sources. Medicinal plants are considered promising candidates because they contain complex mixtures of secondary metabolites that may act against microorganisms through different mechanisms. In this context, *P. amboinicus* leaves have attracted attention as a potential source of natural antibacterial compounds.[18]

Several investigations have demonstrated that extracts prepared from *P. amboinicus* leaves exhibit inhibitory effects against different bacterial species. The antibacterial activity is influenced by factors such as the type of plant extract, extraction solvent, concentration of the extract, bacterial strain, and experimental conditions. Organic solvents such as acetone, ethanol, methanol, and ethyl acetate are commonly used to extract bioactive compounds from the leaves. Differences in solvent polarity can result in the extraction of different groups of phytochemicals and consequently produce variations in antibacterial activity.

The leaves of P. amboinicus were collected in the Laboratory of Pharmaceutical Technology of the Federal University of Paraíba (Brazil) and identified by Dra. Rita de Cássia A. Pereira. A voucher specimen was deposited in the IPA herbarium (Empresa Pernambucana de Pesquisa Agropecuária), under the IPA 65501 number. Plant extracts and Phytochemical screening Crude hydroalcoholic extracts (HE) were prepared by maceration of 2,74 kg remnants of the leaves, with ethanol 70% (v/v), for 72 h. The obtained extract was filtered and concentrated in a rotary evaporator at 45 °C under reduced pressure, yielding 32.5 g. Plant material was screened to detect alkaloids, monoterpenoids, diterpenoids, sesquiterpenoids, triterpenoids, iridoids, saponins, flavonoids, condensed proanthocyanidins [19]

The microorganisms used in this study were Staphylococcus aureus MRSA (ATCC 6538) Staphylococcus aureus (ATCC 25923) and 9 MRSA strains isolated from patients at the University Hospital Lauro Wanderley, João Pessoa, State of Paraiba, Brazil. All strains were obtained from the culture collection of the Department of Molecular Biology, Federal University of Paraíba, Brazil. The antibacterial activity was determined by the Agar Diffusion Assay Method. Petri plates containing 20 mL of medium (Agar Müeller Hinton, DIFCO) were seeded with selected microbial strains. Afterwards, were made cavities of 6 mm of diameter and in each cavity were inoculated 50 µL aliquots of dilution extracts. 70% alcohol was used as negative control and each test was carried out in duplicate. The assessment of antimicrobial activity was based on measurement of inhibition zones formed around the

cavities. The diameters of these zones were recorded. The media was incubated for 24 h at 37 °C.

The results of phytochemical screening of leaves of hydroalcoholic extract from P. amboinicus indicated the presence of flavonoids (caffeic acid, quercetin and luteolin), monoterpenoids (carvacrol), sesquiterpenoids, diterpenoids, triterpenoids, steroids, and condensed proanthocyanidins, leucoanthocyanidins and cinnamics derivatives (chlorogenic acid). The antibacterial activity of the extract in MRSA strains have shown a promising activity against all tested MRSA samples, with holes diameters ranged from 23 to 10 mm, in the concentrations of 150 at 9.3 mg/mL.

The present findings demonstrate that the leaves of *Plectranthus amboinicus* possess significant and promising antibacterial activity, particularly against methicillin-resistant *Staphylococcus aureus* (MRSA), a clinically important pathogen associated with difficult-to-treat infections. The antibacterial effect of the leaf extract may be attributed to the presence of several biologically active phytoconstituents, including carvacrol, essential oils, terpenes, and cinnamic acid derivatives. These compounds are known to interfere with the bacterial cell membrane, increase membrane permeability, disturb cellular integrity, and ultimately cause leakage of intracellular components and cell death.[20]

Antibacterial Activity of *Plectranthus amboinicus* stems

The researchers investigated the methanolic extract of the stem of Plectranthus amboinicus and reported antibacterial activity against selected foodborne pathogenic bacteria.

The stems of Plectranthus amboinicus were collected from plants grown at CSIR-Central Food Technological Research Institute, Mysore, India. The stems were washed, cut into approximately 2 cm pieces, dried at 55°C, powdered and extracted with methanol (1:3 w/v). The extraction was carried out for 24 hours at 30°C, followed by filtration and repeated extraction. The combined extract was concentrated and dried under vacuum.

The methanolic stem extract was tested against selected foodborne pathogens. The study determined the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC).

The results were:

Bacterial organism	MIC of stem extract	MBC of stem extract
Escherichia coli	1750 ppm	2000 ppm
Staphylococcus aureus	1500 ppm	2000 ppm
Bacillus cereus	3000 ppm	5000 ppm
Yersinia enterocolitica	750 ppm	1000 ppm

The strongest antibacterial activity was observed against Yersinia enterocolitica, with the lowest MIC of 750 ppm. The extract also showed activity against E. coli, S. aureus, and B. cereus. However, its activity was weaker than the positive control, nisin.

The stem extract contained several potentially bioactive compounds, including phenolics, flavonoids and condensed tannins. HPLC analysis identified rosmarinic acid, caffeic acid, rutin, gallic acid, quercetin and p-coumaric acid. These compounds may contribute to the observed antibacterial and other biological activities.

The methanolic stem extract of *Plectranthus amboinicus* demonstrated appreciable antibacterial activity against foodborne pathogenic bacteria. The presence of phenolic and flavonoid compounds, particularly rosmarinic acid and related phenolic acids, may contribute to this activity. Therefore, the stem of *Plectranthus amboinicus* can be considered a potential natural source of antibacterial compounds, although further studies are needed before therapeutic use. [21]

CONCLUSION

Plectranthus amboinicus (Lour.) Spreng. is a valuable medicinal plant with considerable antioxidant, antimicrobial, and antibacterial potential. The reviewed studies demonstrate that both leaves and stems contain important bioactive phytoconstituents, including phenolic compounds, flavonoids, tannins, terpenoids, and essential oils. Leaf extracts showed significant antioxidant, antimicrobial, antibiofilm, and antibacterial activities, particularly against *Staphylococcus aureus* and MRSA. The stem also exhibited promising antioxidant activity, with phenolic compounds such as rosmarinic acid contributing substantially to its free-radical-scavenging potential. Antimicrobial activity of the stem was moderate but was associated with its phenolic acids, flavonoids, and diterpenes. The biological activity varied depending on the plant part, extraction solvent, phytochemical composition, and developmental stage of the leaves. Overall, *P. amboinicus* represents a promising natural source of bioactive compounds with potential pharmaceutical and nutraceutical applications. However, further research is required to isolate and characterize the active constituents, determine their mechanisms of action, establish safety, and validate their therapeutic potential through further experimental and clinical studies.

REFERENCE

1. Faisal M, Qahtan AA, Alatar AA. Thidiazuron induced in vitro plant regeneration, phenolic contents, antioxidant potential, GC-MS profiles and nuclear genome stability of Plectranthus amboinicus (Lour.) Spreng. Horticulturae. 2023 Feb 18;9(2):277.
2. Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. LWT – Food Science and Technology, 28(1), 25–30.
3. Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin–Ciocalteu reagent. Methods in Enzymology, 299, 152–178.
4. Govindarajan, R., Vijayakumar, M., & Pushpangadan, P. (2005). Antioxidant approach to disease management and the role of medicinal plants. Journal of Ethnopharmacology, 99(2), 165–178.
5. Kanneboyina, N., et al. (2015). Antioxidant activity and phytochemical screening of ethanolic and aqueous leaf extracts of Plectranthus amboinicus (Lour.) Spreng. International Journal of Pharmacy and Pharmaceutical Sciences, 7(4), 232–236.
6. Kumaran A. and Karunakaran R. J., Antioxidant and free radical scavenging activity of an aqueous extract of *Coleus aromaticus*, *Food Chemistry*. (2006) 97, no. 1, 109–114, 2-s2.0-28844497339
7. El Far M. M. M. and Taie H. A. A., Antioxidant activities, total anthocyanins, phenolics and flavonoids contents of some sweetpotato genotypes under stress of different concentrations of sucrose and sorbitol, *Australian Journal of Basic and Applied Sciences*. (2009) 3, no. 4, 3609–3616, 2-s2.0-77953484479.
8. Sun J. S., Tsuang Y. W., Chen I. J., Huang W. C., Hang Y. S., and Lu F. J., An ultra-weak chemiluminescence study on oxidative stress in rabbits following acute thermal injury, *Burns*. (1998) 24, no. 3, 225–231, 2-s2.0-0032077647
9. Kahl R. and Kappus H., Toxicology of the synthetic antioxidants BHA and BHT in comparison with the natural antioxidant vitamin E, *Zeitschrift für Lebensmittel-Untersuchung und Forschung*. (1993) 196, no. 4, 329–338, 2-s2.0-0027586012
10. Kumaran A. and Karunakaran R. J., *In vitro* antioxidant activities of methanol extracts of five *Phyllanthus* species from India, *LWT—Food Science and Technology*. (2007) 40, no. 2, 344–352, 2-s2.0-33749241354
11. Makino T., Ono T., Muso E., Yoshida H., Honda G., and Sasayama S., Inhibitory effects of rosmarinic acid on the proliferation of cultured murine mesangial cells, *Nephrology Dialysis Transplantation*. (2000) 15, no. 8, 1140–1145, 2-s2.0-0033928839.

12. Bhatt P, Joseph GS, Negi PS, Varadaraj MC. Chemical composition and nutraceutical potential of Indian borage (Plectranthus amboinicus) stem extract. Journal of Chemistry. 2013;2013(1):320329.
13. Sawant S, Baldwin TC, Khan H, Rahman A. Evaluation of the effect of leaf development in *Plectranthus amboinicus* L. on antimicrobial activity and virulence factors of *Pseudomonas aeruginosa* PAO1 and *Staphylococcus aureus* NCTC8325. Curr Microbiol. 2023;80(1):24. doi:10.1007/s00284-022-03126-7.
14. Swamy MK, Arumugam G, Kaur R, Ghasemzadeh A, Yusoff MM, Sinniah UR. GC-MS based metabolite profiling, antioxidant and antimicrobial properties of different solvent extracts of Malaysian Plectranthus amboinicus leaves. Evidence-Based Complementary and Alternative Medicine. 2017;2017(1):1517683.
15. Sivaranjani D, Saranraj P, Manigandan M, Amala K. Antimicrobial activity of Plectranthus amboinicus solvent extracts against Human Pathogenic Bacteria and Fungi. J Drug Delivery & Therapeutics. 2019; 9(3):36-39.
16. Ismayil S, Nimila PJ. Antimicrobial activity of Plectranthus amboinicus against Gram-negative bacteria Klebsiella pneumoniae and Shigella flexneri and their phytochemical tests. Int J Health Sci Res. 2019; 9(5):304-311.
17. Santos Filipe M, Bangay G, Brauning FZ, et al. Plectranthus amboinicus: A Systematic Review of Traditional Uses, Phytochemical Properties, and Therapeutic Applications. Pharmaceuticals. 2025; 18(707):1-32.
18. Negi PS, et al. Antibacterial Activity of Indian Borage (*Plectranthus amboinicus* Benth) Leaf Extracts in Food Systems and Against Natural Microflora in Chicken Meat. *Journal of Food Science and Technology*. 2016.
19. Gurgel APAD, da Silva JG, Grangeiro ARS, Xavier HS, de Oliveira RAG, Pereira MSV, de Souza IA. Antibacterial effects of *Plectranthus amboinicus* (Lour.) Spreng (Lamiaceae) in methicillin resistant *Staphylococcus aureus* (MRSA). Latin American Journal of Pharmacy. 2009;28(3):460–464.
20. de Oliveira RA, de Araújo Neto JA, Agra MF, et al. Efficacy of *Plectranthus amboinicus* (Lour.) Spreng in a murine model of methicillin-resistant *Staphylococcus aureus* skin abscesses. Evidence-Based Complementary and Alternative Medicine. 2013;2013:291592. doi:10.1155/2013/291592.
21. Bhatt P, Joseph GS, Negi PS, Varadaraj MC. Chemical composition and nutraceutical potential of Indian borage (Plectranthus amboinicus) stem extract. Journal of Chemistry. 2013;2013(1):320329.