www.ijarp.com ISSN 2456-9992 Page: 01-09

International Journal Advanced Research Publications

Review Article

Volume: 02
Issue: 07

ANTIMICROBIAL ACTIVITY AND QUALITATIVE PHYTOCHEMICAL COMPOSITION OF CRUDE EXTRACTS FROM MEDICINAL PLANTS: A REVIEW

Dhruv Dutta*[1], Dr Showkat Hussain[2], Ramandeep Kaur[2], Dr Rajender Kumar[3]

[1]M.Sc MLT, Department of Health and Allied Sciences, Guru Kashi University.

[2]Assistant Professor, Faculty of Allied and Healthcare, Guru Kashi University.

[3]Dean, Faculty of Allied and Healthcare, Guru Kashi University.

Article Received: 19 June 2026, Article Revised: 09 July 2026, Published on: 29 July 2026

***Corresponding Author: Dhruv Dutta**

M.Sc MLT, Department of Health and Allied Sciences, Guru Kashi University.

Doi: https://doi-doi.org/101555/ijarp.4569

ABSTRACT

Rising antimicrobial resistance has renewed scientific interest in medicinal plant extracts as sources of alternative antibacterial and antifungal agents. This review synthesizes findings from a laboratory-based study evaluating the antimicrobial activity and qualitative phytochemical composition of leaf extracts from four medicinal plants — Tagetes minuta, Aloe secundiflora, Bulbine frutescens, and Vernonia lasiopus — tested singly and in pairwise combination against clinical isolates of Escherichia coli, Salmonella typhi, Staphylococcus aureus, Shigella flexineri, Enterococcus faecalis, and the yeast Candida albicans. Using the Kirby-Bauer disc diffusion method together with minimum inhibitory and bactericidal/fungicidal concentration assays, all four extracts showed measurable antimicrobial activity, with Tagetes minuta notably effective against Enterococcus faecalis and Staphylococcus aureus, and Bulbine frutescens and Vernonia lasiopus particularly effective against Shigella flexineri and Candida albicans respectively. Combining extracts did not uniformly improve efficacy: some pairings, such as Bulbine frutescens with Vernonia lasiopus against Salmonella typhi and Staphylococcus aureus, produced synergistic increases in inhibition, while others, including Tagetes minuta with Aloe secundiflora against Candida albicans, showed antagonistic reductions relative to their solo performance. Qualitative phytochemical screening confirmed the presence of tannins, flavonoids, alkaloids, and saponins in all four extracts, compounds widely implicated in antimicrobial action through mechanisms such as membrane disruption, nucleic acid interference, and enzyme inhibition.

These findings, considered alongside comparable studies from Kenya, Nigeria, India, Pakistan, and South Africa, support the therapeutic potential of these plants while underscoring the need for further isolation of active compounds and safety evaluation before clinical application.

KEYWORDS: Medicinal plants; Antimicrobial activity; Phytochemicals; Tagetes minuta; Aloe secundiflora; Bulbine frutescens; Vernonia lasiopus; Antibiotic resistance; Synergism.

1. INTRODUCTION

Medicinal plants remain central to healthcare provision worldwide, with an estimated 80% of the global population relying on plant-based remedies, largely because of their affordability and accessibility relative to synthetic pharmaceuticals. This reliance is not a recent development but reflects a continuous human tradition of investigating the healing properties of local flora across civilizations. In recent decades, the growing emergence of antibiotic-resistant bacteria within clinical settings has renewed scientific urgency around plant-derived antimicrobials, since the secondary metabolites that plants produce for their own defense against environmental threats often possess exploitable antibacterial and antifungal properties.

This review is grounded in a laboratory investigation of leaf extracts from four medicinal plants of ethnobotanical significance: Tagetes minuta (Southern Cone Marigold), Aloe secundiflora, Bulbine frutescens, and Vernonia lasiopus. Each plant carries a documented history of traditional use — from herbal teas and gastrointestinal remedies to treatments for malaria, wounds, and skin conditions — alongside emerging scientific evidence of antimicrobial activity. The reviewed study specifically examined leaf extracts, a plant part less frequently studied than the seeds, roots, or whole-plant extracts more commonly reported in prior literature, and evaluated both single-extract and pairwise-combination effects against clinically relevant bacterial and fungal pathogens, alongside qualitative screening for major phytochemical classes.

2. The Medicinal Plants Under Review

2.1 Tagetes minuta

Tagetes minuta, a member of the Asteraceae family native to South America but now naturalized worldwide, has long been used to prepare herbal teas and treat gastrointestinal ailments. Its foliage, flowers, and stems contain flavonoids and terpenes reported to confer antibacterial activity against both Gram-positive and Gram-negative organisms, and essential

oil constituents such as camphene have been linked to activity against pathogens including Staphylococcus aureus.

2.2 Aloe secundiflora

Aloe secundiflora belongs to the diverse Aloe genus, whose members are recognized for antibacterial, antifungal, antiviral, anticancer, and immunomodulatory properties. Traditionally used around Kenya's Lake Victoria region for pulmonary infections, malaria, and abdominal pain, its leaf extracts contain anthraquinones, saponins, and other bioactive compounds associated with broad-spectrum antimicrobial action against both Gram-positive and Gram-negative bacteria.

2.3 Bulbine frutescens

Bulbine frutescens, of the family Xanthorrhoeaceae, has a documented history of use since the 18th century for treating wounds, ringworm, and digestive disorders, particularly among South African communities. It is widely grown as an ornamental plant but is more notable pharmacologically for antibacterial activity attributed to its succulent leaf tissue.

2.4 Vernonia lasiopus

Vernonia lasiopus, a bitter-tasting shrub of the Asteraceae family native to tropical Africa, has been used by East African herbalists to treat malaria, intestinal worms, and digestive disorders. Chemical studies have identified antimicrobial phytochemicals within the plant, consistent with its long-standing ethnomedicinal reputation.

3. Test Microorganisms and Their Clinical Relevance

The six test organisms used in the reviewed study represent clinically significant causes of enteric, cutaneous, and opportunistic infection. Escherichia coli and Salmonella typhi are Gram-negative organisms associated with urinary, systemic, and enteric infections, with typhoid fever alone estimated to cause roughly 269,000 deaths globally in 2010. Staphylococcus aureus, a Gram-positive organism, causes skin infections, food poisoning, and toxic shock, with rising antibiotic use driving resistance. Shigella flexineri causes shigellosis, responsible for an estimated one million deaths annually, largely in settings with inadequate sanitation. Enterococcus faecalis, though often commensal, is increasingly implicated in nosocomial infections including bacteremia and endocarditis. Candida albicans, part of normal human mucosal flora, causes systemic candidiasis in immunocompromised individuals and has shown rising resistance to synthetic antifungals. The resistance trends documented across all six organisms motivate the search for plant-derived alternatives evaluated in this review.

4. Phytochemical Classes and Proposed Mechanisms

Qualitative screening across the reviewed literature consistently identifies four major phytochemical classes in antimicrobial plant extracts: tannins, flavonoids, alkaloids, and saponins. Tannins are water-soluble phenolic compounds that bind proteins and other biomolecules, conferring antibacterial, antifungal, and antiviral effects alongside antioxidant and antimutagenic properties. Flavonoids, a class of over 500 identified compounds, are reported to inhibit nucleic acid synthesis and disrupt bacterial membrane integrity and energy metabolism, and have shown synergy when combined with conventional antibiotics. Alkaloids, nitrogen-containing secondary metabolites, display a broad pharmacological profile including antibacterial activity against organisms such as Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa, in some cases through intercalation into microbial DNA. Saponins, amphipathic glycosides, are thought to act primarily by lysing microbial cell membranes, with reported effectiveness against E. coli, S. typhi, and Candida albicans. The reviewed study's qualitative testing confirmed the presence of all four compound classes in each of the four plant extracts, providing a plausible phytochemical basis for the antimicrobial activity observed.

5. Methodological Approach

The reviewed investigation used leaf extracts prepared by methanol maceration and evaporated to yield concentrated stock solutions, tested via the Kirby-Bauer disc diffusion method on Mueller-Hinton agar for bacteria and potato dextrose agar for Candida albicans. Zones of inhibition were compared against ciprofloxacin, vancomycin, or fluconazole positive controls and methanol/DMSO negative controls, with one-way and two-way ANOVA followed by Tukey's post hoc test used to assess statistical significance ($P \leq 0.05$). Minimum inhibitory concentrations were determined by broth microdilution, and minimum bactericidal/fungicidal concentrations were established by subculturing wells showing no visible growth. Combination effects were tested for all six pairwise combinations of the four extracts at a 1:1 ratio, and qualitative phytochemical screening used standard color- and precipitate-based tests for tannins, flavonoids, alkaloids, and saponins.

6. Antimicrobial Efficacy of Single Extracts

All four plant extracts demonstrated measurable antimicrobial activity against every test organism, though efficacy varied by plant-pathogen pairing. Tagetes minuta produced the largest zones of inhibition against Salmonella typhi, Staphylococcus aureus, and

Enterococcus faecalis; Aloe secundiflora was most effective against Escherichia coli; Bulbine frutescens performed best against Shigella flexineri; and Vernonia lasiopus was most effective against Candida albicans. Across all pairings, plant extracts produced significantly smaller inhibition zones than the relevant positive-control antibiotic but significantly larger zones than the DMSO negative control, consistent with genuine, if moderate, antimicrobial activity rather than an artifact of the testing method.

Extract	Most Sensitive Organism	Largest Zone (mm)	Lowest MIC (µg/mL)
Tagetes minuta	Enterococcus faecalis	18.67 ± 1.03	5.1 (E. faecalis)
Aloe secundiflora	Escherichia coli	16.67 ± 2.58	3.7 (S. flexineri)
Bulbine frutescens	Shigella flexineri	19.50 ± 1.05	3.2 (S. flexineri)
Vernonia lasiopus	Candida albicans	20.17 ± 2.71	3.3 (S. flexineri)

Minimum inhibitory concentration data showed that, while all extracts were active at relatively low concentrations (roughly 3–13 µg/mL for most extract-pathogen combinations), the standard antibiotics remained more potent against most bacteria, with the notable exception of Candida albicans, where all four plant extracts outperformed fluconazole, the positive control, at lower concentrations. This finding is particularly notable given the rising resistance of Candida albicans to synthetic antifungals reported elsewhere in the literature.

7. Combined Extract Effects: Synergism and Antagonism

Testing pairwise combinations of the four extracts revealed that combination did not uniformly enhance antimicrobial activity, a central and somewhat unexpected finding of the reviewed study. Against Escherichia coli, several combinations — including Bulbine frutescens with Vernonia lasiopus and with Tagetes minuta — produced larger inhibition zones than either extract alone, indicating synergy. Similarly, against Salmonella typhi and Staphylococcus aureus, specific pairings involving Bulbine frutescens, Aloe secundiflora, and Vernonia lasiopus enhanced antimicrobial activity relative to individual extracts. By contrast, combinations tested against Enterococcus faecalis consistently showed reduced antimicrobial activity compared with the corresponding solo extracts, and the pairing of Tagetes minuta with Aloe secundiflora against Candida albicans produced a markedly smaller inhibition zone than either extract used alone, indicating an antagonistic interaction.

These mixed results suggest that combining plant extracts can shift antimicrobial outcomes in either direction depending on the specific pathogen and extract pairing, likely reflecting differences in the compatibility of the phytochemical profiles involved — for instance, competitive binding, chemical interference between compound classes, or differential solubility when extracts are mixed. This pattern is consistent with prior reports of both synergistic and antagonistic combination effects in the wider literature on medicinal plant extracts, and reinforces the point that combination therapy cannot be assumed beneficial without pathogen-specific empirical testing.

8. Comparison with Published Literature

The findings reviewed here align closely with prior studies from multiple regions. Aloe secundiflora's broad-spectrum activity corresponds with earlier Kenyan work around the Lake Victoria region and with Nigerian and English studies on related Aloe species, while Tagetes minuta's efficacy against Staphylococcus aureus matches findings from India and Pakistan at comparable zone-of-inhibition thresholds. Some discrepancies were also noted: reported minimum inhibitory concentrations for Bulbine frutescens against Staphylococcus aureus and Escherichia coli differed from a South African study, a divergence plausibly attributable to differences in growing conditions, extraction technique, or plant age rather than a fundamental disagreement about the plant's antimicrobial potential. Comparable variability was observed for Vernonia lasiopus, where results partly agreed and partly disagreed with earlier Kenyan findings depending on the test organism and extraction method used. Across the literature, phytochemical screening consistently identifies tannins, flavonoids, alkaloids, and saponins in these plant genera, though occasional discrepancies — such as one Nigerian study failing to detect alkaloids in Vernonia lasiopus — point to geographic and ecological variation in phytochemical expression.

9. DISCUSSION

Taken together, the evidence reviewed here supports the therapeutic promise of Tagetes minuta, Aloe secundiflora, Bulbine frutescens, and Vernonia lasiopus as sources of antimicrobial compounds active against a range of clinically significant bacteria and Candida albicans. The consistent presence of tannins, flavonoids, alkaloids, and saponins across all four extracts, combined with the well-documented mechanisms by which these compound classes disrupt microbial membranes, nucleic acid synthesis, and metabolic processes, offers a plausible chemical basis for the observed antimicrobial effects. The particularly strong

performance of all four extracts against Candida albicans relative to fluconazole is noteworthy given the global rise in antifungal resistance, and merits focused follow-up research.

At the same time, the inconsistent effect of combining extracts — beneficial for some pathogen-extract pairs and detrimental for others — cautions against assuming that herbal combination therapies are inherently superior to single-extract treatments. This variability likely reflects underlying phytochemical interactions that are not yet well characterized and that would need to be resolved through targeted chemical fractionation studies before combination therapies could be rationally designed. The moderate but real activity of these extracts relative to standard antibiotics, together with their traditional use across multiple cultures, supports their consideration as adjuncts or alternatives to conventional antimicrobials, particularly in resource-limited settings where access to synthetic drugs may be constrained.

Several limitations should be noted. Qualitative phytochemical screening establishes only presence or absence of major compound classes rather than the specific active constituents responsible for antimicrobial effects, so isolating and characterizing these compounds remains an essential next step. The use of a single 1:1 combination ratio for paired extracts also leaves open the possibility that different ratios could shift synergistic or antagonistic outcomes, and clinical translation of these findings would require formal safety and toxicity evaluation, which fell outside the scope of the reviewed laboratory work.

10. CONCLUSION AND FUTURE DIRECTIONS

This review confirms that leaf extracts of Tagetes minuta, Aloe secundiflora, Bulbine frutescens, and Vernonia lasiopus possess measurable antimicrobial activity against clinically relevant Gram-positive and Gram-negative bacteria as well as Candida albicans, underpinned by a shared phytochemical profile of tannins, flavonoids, alkaloids, and saponins. Combining extracts produced pathogen-specific synergistic or antagonistic effects rather than a uniform improvement, highlighting the need for empirical, rather than assumed, evaluation of combination therapies. These findings reinforce the broader case for medicinal plants as a viable source of novel antimicrobial agents amid rising global antibiotic and antifungal resistance.

Future work should prioritize isolation and structural characterization of the specific bioactive compounds responsible for the observed activity, systematic testing of combination ratios beyond 1:1 to map the full synergy-antagonism landscape, and formal toxicological

and safety assessment ahead of any pharmaceutical development. Extending testing to additional clinical isolates, drug-resistant strains, and in vivo models would further strengthen the translational relevance of these findings toward standardized, plant-derived antimicrobial therapies.

REFERENCES

1. Abdel Ghani, S. B., Mugisha, P. J., Wilcox, J. C., Gado, E. A., Medu, E. O., Lamb, A. J., & Brown, R. C. (2013). Convenient one-pot synthesis of chromone derivatives and their antifungal and antibacterial evaluation. Synthetic Communications, 43(11), 1549–1556.
2. Aboaba, O., & Efuwape, B. M. (2001). Antibacterial properties of some Nigerian species. Biochemical and Biophysical Research Communications, 13, 183–188.
3. Adwan, G., & Mhanna, M. (2008). Synergistic effects of plant extracts and antibiotics on Staphylococcus aureus strains isolated from clinical specimens. Middle-East Journal of Scientific Research, 3(3), 134–139.
4. Adwan, G., Salameh, Y., & Adwan, K. (2011). Effect of ethanolic extract of Ecballium elaterium against Staphylococcus aureus and Candida albicans. Asian Pacific Journal of Tropical Biomedicine, 1(6), 456–460.
5. Afolayan, A. J. (2003). Extracts from the shoots of Arctotis arctotoides inhibit the growth of bacteria and fungi. Pharmaceutical Biology, 41(1), 22–25.
6. Agarry, O. O., & Olaleye, M. T. (2005). Comparative antimicrobial activities of Aloe vera gel and leaf. African Journal of Biotechnology, 4(12), 1410–1413.
7. Akiyama, H., Fujii, K., Yamasaki, O., Oono, T., & Iwatsuki, K. (2001). Antibacterial action of several tannins against Staphylococcus aureus. Journal of Antimicrobial Chemotherapy, 48(4), 487–491.
8. Alzoreky, N. S., & Nakahara, K. (2003). Antibacterial activity of extracts from some edible plants commonly consumed in Asia. International Journal of Food Microbiology, 80(3), 223–230.
9. Buckle, G. C., Walker, C. L., & Black, R. E. (2012). Typhoid fever: A systematic review of global incidence and mortality. Journal of Global Health, 2(1), 010401.
10. Chanda, S., & Rakholiya, K. (2011). Combination therapy: Synergism between natural plant extracts and antibiotics against infectious diseases. In Science against Microbial Pathogens: Communicating Current Research and Technological Advances.
11. Coopoosamy, R. M. (2011). Traditional information and antibacterial activity of four Bulbine species. African Journal of Biotechnology, 10(3), 220–224.
12. Cowan, M. M. (1999). Plant products as antimicrobial agents. Clinical Microbiology Reviews, 12(4), 564–582.

13. Cushnie, T. T., & Lamb, A. J. (2005). Antimicrobial activity of flavonoids. International Journal of Antimicrobial Agents, 26(5), 343–356.
14. Cushnie, T. T., & Lamb, A. J. (2014). Alkaloids: An overview of their antibacterial, antibiotic-enhancing and antivirulence activities. International Journal of Antimicrobial Agents, 44(5), 377–386.
15. Eloff, J. N. (1998). A sensitive and quick microplate method to determine the minimal inhibitory concentration of plant extracts for bacteria. Planta Medica, 64(8), 711–713.
16. Fabricant, D. S., & Farnsworth, N. R. (2001). The value of plants used in traditional medicine for drug discovery. Environmental Health Perspectives, 109(Suppl 1), 69–75.
17. Kaingu, F., Kibor, A., Waihenya, R., Shivairo, R., & Mungai, L. (2013). Antibacterial activity of Aloe secundiflora leaf extracts against selected pathogenic bacteria. International Journal of Herbal Medicine, 1(3), 27–33.
18. Kareru, P. G., Kenji, G. M., Gachanja, A. N., Keriko, J. M., & Mungai, G. (2007). Traditional medicines among the Embu and Mbeere peoples of Kenya. African Journal of Traditional, Complementary and Alternative Medicines, 4(1), 75–86.
19. Kotloff, K. L., Winickoff, J. P., Ivanoff, B., Clemens, J. D., Swerdlow, D. L., Sansonetti, P. J., Adak, G. K., & Levine, M. M. (1999). Global burden of Shigella infections. Bulletin of the World Health Organization, 77(8), 651–666.
20. Mariita, R. M., Ogol, C. K. P. O., Oguge, N. O., & Okemo, P. O. (2011). Methanolic extracts of Aloe secundiflora Engl. inhibits in vitro growth of tuberculosis and diarrhoea-causing bacteria. Pharmacognosy Research, 3(2), 95–99.
21. Ndhlala, A. R., Stafford, G. I., Finnie, J. F., & Van Staden, J. (2009). In vitro pharmacological effects of manufactured herbal concoctions used in KwaZulu-Natal, South Africa. Journal of Ethnopharmacology, 122(1), 117–122.
22. Pfaller, M. A., Diekema, D. J., & International Fungal Surveillance Participant Group. (2007). Epidemiology of invasive candidiasis: A persistent public health problem. Clinical Microbiology Reviews, 20(1), 133–163.
23. Tahir, M., & Khan, M. A. (2012). Antimicrobial screening of Tagetes minuta extracts against selected bacterial pathogens. Pakistan Journal of Botany, 44(4), 1385–1389.
24. Tereschuk, M. L., Riera, M. V. Q., Castro, G. R., & Abdala, L. R. (1997). Antimicrobial activity of flavonoids from leaves of Tagetes minuta. Journal of Ethnopharmacology, 56(3), 227–232.
25. Van Wyk, B. E., & Gericke, N. (2000). People's plants: A guide to useful plants of Southern Africa. Briza Publications.