International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 5 Sept - Oct 2025, pp: 1423-1431 www.ijprajournal.com ISSN: 2456-4494

Ethnomedicinal Significance and Antimicrobial Applications of Grewia asiatica and Anacyclus radiatus

Km.stuti[1] and Santosh Kumar Shukla[2]

1. Student, Department of Pharmaceutical Chemistry, Institute of Pharmaceutical Sciences & Research,Mahadev Campus, NH 25, Kanpur - Lucknow Rd, Sohramau, Lucknow, Lalpur, Uttar Pradesh 209859.

2. Assistant Professor, Department of Pharmaceutical Chemistry, Institute of Pharmaceutical Sciences & Research,Mahadev Campus, NH 25, Kanpur - Lucknow Rd, Sohramau, Lucknow, Lalpur, Uttar Pradesh 209859

Corresponding author: *Km.stuti*

Date of Submission: 01-11-2025 Date of Acceptance: 10-11-2025

ABSTRACT

Grewia asiatica (commonly known as Phalsa) and Anacyclus radiatus are two important medicinal plants traditionally valued for their diverse therapeutic applications. Grewia asiatica has long been used in folk medicine for its cooling, antioxidant, anti-inflammatory, and antimicrobial properties, while Anacyclus radiatus is recognized for its use in treating infections, fever, and inflammatory disorders. Both plants are rich in bioactive phytoconstituents such as flavonoids, alkaloids, tannins, saponins, and phenolic compounds, which contribute significantly to their antimicrobial potential. The comparative evaluation of these two plants provides insights into their ethnomedicinal relevance and their role as potential natural sources of antibacterial and antifungal agents. This review aims to summarize the phytochemical profiles, traditional medicinal uses, and antimicrobial efficacy of Grewia asiatica and Anacyclus radiatus, highlighting their potential as promising candidates for herbal drug development and formulation. Such studies not only validate traditional knowledge but also open avenues for the discovery of novel plant-based therapeutics against microbial infections.

Keywords: Grewia asiatica, Anacyclus radiatus, ethnomedicine, antimicrobial activity, phytochemistry, traditional medicine, herbal therapeutics.

I. INTRODUCTION

The alarming rise of microbial resistance has emerged as one of the most pressing global health challenges of the 21st century. The widespread and often indiscriminate use of antibiotics in clinical practice, agriculture, and animal husbandry has led to the evolution of multi-drug-resistant strains of bacteria and fungi. These resistant pathogens not only reduce the efficacy of existing antimicrobial therapies but also contribute to prolonged illnesses, increased healthcare costs, and higher mortality rates. Consequently, there is a growing demand for alternative therapeutic strategies that are effective, safe, and environmentally sustainable. In this context, plant-derived antimicrobials have garnered immense interest due to their structural diversity, biocompatibility, and lower propensity for resistance development.

Medicinal plants have been an integral part of traditional healthcare systems such as Ayurveda, Siddha, Unani, and traditional Chinese medicine for thousands of years. These systems rely heavily on ethnopharmacological knowledge—wisdom passed down through generations regarding the healing potential of plants and their natural products. Plants synthesize a wide array of secondary metabolites—including alkaloids, flavonoids, saponins, tannins, terpenoids, and phenolic acids—that play crucial roles in their defense mechanisms against microbial invasion, oxidative stress, and environmental challenges. Many of these compounds have demonstrated potent antimicrobial, anti-inflammatory, antioxidant, and immunomodulatory effects in scientific studies, validating their traditional therapeutic claims.

Among the numerous plants studied for their antimicrobial efficacy, Grewia asiatica (commonly known as Phalsa) and Anacyclus radiatus (Spanish Chamomile) have attracted scientific attention due to their long-standing ethnomedicinal use and rich phytochemical composition. Grewia asiatica, a member of the Malvaceae family, is native to South Asia and is widely cultivated for its small purple fruits that are used in refreshing beverages and traditional tonics.

The plant has been used in Ayurvedic medicine for the treatment of fever, diarrhea, inflammation, respiratory ailments, and microbial infections. Its root and bark extracts are traditionally applied for skin diseases and wound healing, indicating possible antibacterial and antifungal activities.

Anacyclus radiatus, belonging to the Asteraceae family, is an aromatic herb native to the Mediterranean and North African regions. It is closely related to Anacyclus pyrethrum, a well-known medicinal plant used as a nerve tonic and aphrodisiac. Traditionally, A. radiatus has been used to treat fever, infections, and inflammatory disorders. Its essential oils and root extracts have demonstrated antimicrobial, analgesic, and antioxidant properties in various studies. The plant's ethnobotanical relevance and biochemical richness make it a valuable candidate for pharmacological evaluation and potential drug discovery.

The objective of this review is to present a comparative analysis of the ethnomedicinal significance, phytochemical constituents, and antimicrobial properties of Grewia asiatica and Anacyclus radiatus. This comparative evaluation aims to bridge the gap between traditional knowledge and scientific validation, thereby promoting the rational development of herbal therapeutics and novel antimicrobial agents. Furthermore, understanding the bioactive compounds and mechanisms of action of these plants could contribute to the identification of new leads for natural product-based drug discovery.

II. BOTANICAL DESCRIPTION

2.1 Grewia asiatica

Fig. Grewia asiatica, plant, fruit, flower

Family: Malvaceae

Common name: Phalsa

Distribution: India, Pakistan, Sri Lanka, Bangladesh, and Southeast Asia

Grewia asiatica L. is a small, deciduous shrub or small tree that typically grows between 3 to 4 meters in height. It is extensively cultivated across the Indian subcontinent, particularly in dry and semi-arid regions, for its edible fruits and medicinal importance. The plant thrives in warm, subtropical climates and prefers sandy loam soils with good drainage.

The stem is woody, brownish-gray, and covered with fine pubescence. The leaves are simple, alternate, and broadly ovate with a serrated margin and acute apex. The upper surface of the leaf is rough and dark green, while the underside is soft and covered with short hairs. The flowers are small, yellowish, and borne in axillary or terminal cymes, blooming during the spring and early summer months. The fruits are small, round, and turn dark purple to black upon ripening, containing a sweet-sour pulp that is rich in vitamins, minerals, and antioxidants such as anthocyanins and flavonoids.

The root system is well-developed and contains several bioactive phytochemicals including tannins, alkaloids, saponins, and glycosides. These compounds contribute to its traditional use in treating inflammation, wounds, diarrhea, and microbial infections. Various studies have reported the presence of pharmacologically active compounds such as lupeol, β-sitosterol, quercetin, catechin, and gallic acid, which are known for their potent antimicrobial and antioxidant properties. The plant is widely recognized in traditional medicine for its cooling effect, cardiotonic action, and its ability to alleviate inflammatory and infectious conditions, making it a promising candidate for further pharmacological exploration.

2.2 Anacyclus radiatus

Fig. Anacyclus radiatus

Family: Asteraceae

Common name: Spanish Chamomile

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 5 Sept - Oct 2025, pp: 1423-1431 www.ijprajournal.com ISSN: 2456-4494

Distribution: Mediterranean Basin, North Africa (Algeria, Morocco, Tunisia), Southern Europe (Spain, Italy, Greece), and parts of the Middle East

Anacyclus radiatus Loisel. is an annual herbaceous plant that grows naturally in sunny, dry habitats such as grasslands, roadsides, and rocky terrains. It typically attains a height of 20–40 cm and thrives in well-drained, sandy, or calcareous soils characteristic of Mediterranean climates.

The stem is slender, branched, and often pubescent, giving the plant a soft texture. The leaves are alternate, finely divided, and pinnatifid, with lobes that are linear and slightly toothed, imparting a feathery appearance. The inflorescence consists of solitary, terminal flower heads with yellow central disc florets surrounded by white or pale yellow ray florets. The flowering season usually extends from April to July, depending on environmental conditions. The fruit is a small, dry achene containing a single seed.

The roots of A. radiatus are aromatic and contain a variety of volatile oils and secondary metabolites such as alkylamides, terpenoids, sesquiterpene lactones, and phenolic compounds. These constituents are responsible for the plant's characteristic fragrance and therapeutic effects. Traditionally, A. radiatus has been employed in herbal medicine for treating microbial infections, fever, toothache, and digestive disorders. Scientific investigations have revealed that its extracts exhibit broad-spectrum antibacterial and antifungal activity, likely due to the synergistic action of its essential oils and phenolic compounds. Additionally, the plant has demonstrated anti-inflammatory, analgesic, and antioxidant activities, making it an important candidate for pharmacognostic and phytopharmacological research.

III. ETHNOMEDICINAL SIGNIFICANCE

3.1 Traditional Uses of Grewia asiatica

Grewia asiatica L., commonly known as Phalsa, holds a significant position in traditional medicine, especially in Ayurvedic and Unani systems of healing. It has been utilized for centuries across India, Pakistan, Bangladesh, and other parts of Southeast Asia for its diverse pharmacological properties. In traditional Ayurvedic texts, the fruits, bark, leaves, and roots of Grewia asiatica are mentioned as remedies for ailments related to fever, inflammation, thirst, diarrhea, respiratory infections, and liver disorders.

The fruits are particularly valued for their cooling, refreshing, and antioxidant properties. They are often consumed during the summer months as natural beverages to alleviate heat exhaustion and dehydration. Rich in vitamins (especially vitamin C), anthocyanins, and flavonoids, the fruit juice acts as a natural cooling agent, helps in detoxification, and provides relief from fever and sore throat.

The bark and leaves of Grewia asiatica have been traditionally used in the form of pastes and decoctions to treat wounds, skin infections, and microbial inflammations. They are known to possess antimicrobial, anti-inflammatory, and wound-healing properties, which are attributed to their high content of tannins and phenolic compounds.

The root extract of Grewia asiatica is used in folk medicine for its antipyretic (fever-reducing) and hepatoprotective (liver-protecting) effects. In rural areas, root decoctions are administered to individuals suffering from chronic fever, liver enlargement, and gastric disturbances. Studies have also reported its use in relieving joint pain, cough, and respiratory ailments. The holistic use of the entire plant highlights its ethnomedicinal importance and its potential as a source of bioactive compounds for modern pharmacological applications.

3.2 Traditional Uses of Anacyclus radiatus

Anacyclus radiatus Loisel., commonly referred to as Spanish Chamomile, has been widely used in Mediterranean, North African, and Middle Eastern traditional medicine. The plant's ethnomedicinal applications are diverse, with both its roots and aerial parts being utilized for therapeutic purposes. The root of Anacyclus radiatus is highly esteemed as a tonic, stimulant, and aphrodisiac, similar to its relative Anacyclus pyrethrum. It is used to enhance physical strength, stimulate appetite, and improve vitality.

Traditionally, the root and whole-plant decoctions are employed to alleviate toothache, dyspepsia (indigestion), and fever. The decoction is also used as a gargle for oral infections due to its antimicrobial and anti-inflammatory properties. In traditional Unani medicine, A. radiatus is prescribed for ailments involving the nervous system, including paralysis, neuralgia, and mental fatigue, due to its reported nerve-stimulating properties.

The essential oils and root extracts are used externally to relieve pain, inflammation, and skin infections. Modern ethnopharmacological studies have validated many of these uses, showing that A. radiatus extracts possess anti-inflammatory, antimicrobial, antioxidant, and analgesic effects. Its ethnomedicinal applications, combined with recent pharmacological evidence, support the traditional use of this herb as a valuable source of natural therapeutic agents.

IV. PHYTOCHEMICAL CONSTITUENTS

4.1 Grewia asiatica

The phytochemical composition of Grewia asiatica has been extensively studied, revealing a diverse array of bioactive compounds responsible for its pharmacological effects. The major groups of phytoconstituents include flavonoids, tannins, saponins, alkaloids, glycosides, phenolic acids, and anthocyanins.

Among the flavonoids, quercetin and kaempferol are predominant and contribute significantly to the plant's antioxidant, antibacterial, and anti-inflammatory properties. The fruits are rich in anthocyanins, particularly delphinidin and cyanidin derivatives, which exhibit potent free radical scavenging activity and protect biological systems from oxidative stress.

The bark and leaves are rich in tannins and saponins, which play a crucial role in antimicrobial defense by disrupting bacterial cell walls and inactivating microbial enzymes. The roots contain a notable concentration of alkaloids and glycosides, along with secondary metabolites such as lupeol, β-sitosterol, catechin, gallic acid, and ellagic acid, which have shown antibacterial, hepatoprotective, and anti-inflammatory activity.

The synergistic effect of these compounds contributes to the wide range of therapeutic applications of Grewia asiatica. The plant's phytoconstituents act by neutralizing reactive oxygen species (ROS), modulating inflammatory pathways, and inhibiting microbial enzymes, thereby confirming its medicinal significance.

4.2 Anacyclus radiatus

Anacyclus radiatus contains a rich variety of phytochemicals that account for its wide pharmacological activity. The plant has been found to possess alkaloids, sesquiterpene lactones, flavonoids, tannins, saponins, terpenoids, and coumarins.

Among these, the alkaloids anacyclin and pellitorine are the most significant bioactive compounds known for their antimicrobial, antifungal, and analgesic properties. β-sitosterol, a phytosterol present in the plant, contributes to its anti-inflammatory and antioxidant activities by modulating inflammatory mediators and stabilizing cellular membranes. The presence of sesquiterpene lactones enhances its antimicrobial and antifungal potential by disrupting microbial membrane integrity and inhibiting spore germination.

Flavonoids and phenolic compounds further contribute to the scavenging of free radicals and reduction of oxidative damage in biological systems. The complex mixture of these compounds provides A. radiatus with multifaceted pharmacological effects, supporting its use in traditional medicine for infections, inflammation, and nervous disorders.

Plant Name	Major Phytochemical Constituents	Notable Bioactive Compounds	Pharmacological / Biological Role
Grewia asiatica (Phalsa)	Flavonoids, tannins, saponins, alkaloids, glycosides, phenolic acids, anthocyanins	Quercetin, Kaempferol, Delphinidin, Cyanidin, Catechin, Lupeol, β-sitosterol, Gallic acid, Ellagic acid	Antioxidant, antibacterial, anti-inflammatory, hepatoprotective, wound healing
Anacyclus radiatus (Spanish Chamomile)	Alkaloids, sesquiterpene lactones, flavonoids, tannins, saponins, terpenoids, coumarins	Anacyclin, Pellitorine, β-sitosterol, Sesquiterpene lactones, Phenolic acids	Antimicrobial, antifungal, antioxidant, anti-inflammatory, analgesic
Comparative Observation	Both plants contain flavonoids, tannins, and saponins as major antimicrobial agents.	Flavonoids (quercetin, kaempferol) and alkaloids (anacyclin, pellitorine) show synergistic effects.	Exhibit strong antioxidant and antimicrobial synergy.

Table 1: Phytochemical Constituents of Grewia asiatica and Anacyclusradiatu

V. ANTIMICROBIAL ACTIVITIES

5.1 Grewia asiatica

The antimicrobial potential of Grewia asiatica has been validated through various in vitro studies employing different solvent extracts. Methanolic and ethanolic extracts of the roots, bark, and leaves have demonstrated significant inhibitory effects against both Gram-positive and Gram-negative bacteria, including Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, and Bacillus subtilis. The effectiveness of the extracts varies with solvent polarity, with methanol and ethanol showing the highest extraction efficiency for active phytochemicals.

The mechanism of action of Grewia asiatica extracts involves multiple pathways such as disruption of bacterial cell membrane integrity, leakage of cellular contents, and inhibition of bacterial enzyme systems involved in metabolic processes. The flavonoids and tannins present in the extracts interfere with bacterial adhesion, protein synthesis, and nucleic acid formation.

Interestingly, recent studies have revealed a synergistic effect between Grewia asiatica extracts and standard antibiotics. When combined with conventional antibacterial drugs, the extracts enhanced the overall inhibitory effect, particularly against drug-resistant bacterial strains. This suggests that Grewia asiatica could serve as a valuable adjunct therapy in combating antibiotic resistance. Furthermore, the plant's extracts have also demonstrated mild antifungal activity, suggesting a broader antimicrobial spectrum.

5.2 Anacyclus radiatus

Anacyclus radiatus has been reported to exhibit broad-spectrum antibacterial and antifungal activities, attributed to its rich content of bioactive secondary metabolites. Experimental studies using methanol, chloroform, and aqueous extracts have demonstrated strong inhibition against several microbial species, including Bacillus subtilis, Staphylococcus aureus, Escherichia coli, and the fungal pathogen Candida albicans.

The methanolic and chloroform extracts are found to be the most active, suggesting that the major antimicrobial compounds—such as anacyclin, pellitorine, and sesquiterpene lactones—are better soluble in non-polar and semi-polar solvents. These extracts have shown zones of inhibition comparable to standard antibiotics, confirming their potent antimicrobial nature.

The mechanism of action is thought to involve permeabilization of microbial membranes, inhibition of spore germination, and interference with essential metabolic pathways. Additionally, the essential oils from A. radiatus exhibit strong antifungal effects, possibly due to their volatile constituents disrupting fungal cell wall integrity and ergosterol biosynthesis.

The combined antibacterial and antifungal potential of Anacyclus radiatus highlights its value as a natural source of bioactive compounds that can be further explored for the development of herbal antimicrobial formulations and novel phytopharmaceuticals aimed at managing infectious diseases, especially those caused by resistant pathogens.

VI. COMPARATIVE ANALYSIS

Parameters	**Grewia asiatica**	**Anacyclus radiatus**
Family	Malvaceae	Asteraceae
Key Compounds	Flavonoids, tannins, anthocyanins	Alkaloids, sesquiterpenes
Major Activity	Antioxidant, antibacterial	Antibacterial, antifungal
Traditional Uses	Cooling, wound healing, hepatoprotective	Tonic, aphrodisiac, toothache remedy
Solvent showing maximum activity	Methanol	Methanol, chloroform

Table 1: Comparative Analysis

VII. MECHANISM OF ANTIMICROBIAL ACTION

The antimicrobial action of Grewia asiatica and Anacyclus radiatus can be attributed to the synergistic activity of their diverse bioactive phytoconstituents, such as flavonoids, alkaloids, tannins, terpenoids, and phenolic compounds. These natural metabolites act through multiple mechanisms, targeting essential components and functions of microbial cells, leading to their growth inhibition or death.

Firstly, both plants exhibit the ability to interfere with bacterial cell wall synthesis. Phytochemicals such as tannins and flavonoids disrupt the structural integrity of the peptidoglycan layer, weakening the bacterial cell wall and increasing its permeability. This action makes bacteria more vulnerable to osmotic stress and eventual lysis.

Secondly, the extracts induce disruption of the microbial cell membrane, leading to leakage of cytoplasmic contents. Nonpolar compounds such as terpenoids and sterols integrate into the lipid bilayer, causing disorganization of membrane lipids and proteins. This results in the efflux of vital cellular materials such as ions, nucleotides, and proteins, which leads to the collapse of metabolic functions and cell death.

Another important mode of action involves the inhibition of microbial enzymes and protein synthesis. Flavonoids and alkaloids can interact with microbial ribosomes, impairing translation processes, while phenolic acids inhibit key metabolic enzymes such as DNA gyrase and RNA polymerase. This interference hampers nucleic acid replication and energy production, thereby suppressing microbial proliferation.

Furthermore, several phenolic and flavonoid compounds act as inducers of oxidative stress in microbial cells. These molecules promote the generation of reactive oxygen species (ROS), including hydrogen peroxide and superoxide radicals, which damage cellular macromolecules like lipids, proteins, and DNA. The cumulative oxidative damage ultimately leads to apoptosis-like cell death in microorganisms.

Collectively, these multifaceted mechanisms not only enhance the antimicrobial potency of Grewia asiatica and Anacyclus radiatus but also reduce the risk of resistance development, as pathogens find it difficult to adapt to such multi-targeted modes of action.

VIII. PHARMACOLOGICAL RELEVANCE AND APPLICATIONS

The broad-spectrum antimicrobial potential of Grewia asiatica and Anacyclus radiatus positions them as promising candidates for herbal drug development. Their bioactive compounds—particularly flavonoids, alkaloids, and terpenoids—demonstrate activities comparable to synthetic antibiotics, yet with lower cytotoxicity and minimal side effects.

One of the key pharmacological implications lies in their potential use as natural sources for developing novel antimicrobial agents. Extracts from these plants can be employed in the formulation of herbal ointments, gels, mouthwashes, and topical creams for the treatment of bacterial and fungal infections, especially those affecting the skin, oral cavity, and wounds. Their anti-inflammatory and antioxidant properties further enhance wound healing and tissue regeneration, providing a dual therapeutic effect.

Additionally, the synergistic potential of these extracts with conventional antibiotics opens up new avenues in the fight against antibiotic-resistant pathogens. Studies have demonstrated that certain phytochemicals can restore the sensitivity of resistant bacteria by inhibiting efflux pumps and altering membrane permeability, thereby enhancing antibiotic efficacy. This combination therapy approach could significantly reduce the required dosage of synthetic antibiotics, minimizing adverse effects and resistance development.

However, to fully harness their potential, bioassay-guided isolation and characterization of the active constituents are necessary. Identifying and purifying specific molecules responsible for antimicrobial activity will enable the design of more effective phytopharmaceuticals with consistent potency and defined mechanisms of action.

Moreover, incorporating these plant extracts into cosmeceutical and nutraceutical formulations could add further value, providing natural antimicrobial protection in skincare, oral hygiene, and dietary supplement products.

IX. FUTURE PROSPECTS

While both Grewia asiatica and Anacyclus radiatus have demonstrated considerable antimicrobial efficacy in in vitro studies, further research is essential to translate these findings into clinical and pharmaceutical applications. Several promising future directions can be outlined:

1. **Exploration of Synergistic Effects:**

Combining the extracts of Grewia asiatica and Anacyclus radiatus could yield enhanced antimicrobial efficacy through synergistic interactions among their phytoconstituents. This approach can potentially broaden their antimicrobial spectrum and reduce the emergence of resistant strains.

2. **In Vivo and Toxicological Studies:**

Comprehensive in vivo experiments and toxicological assessments are necessary to evaluate safety, pharmacokinetics, and efficacy in biological systems. Establishing therapeutic dosage, bioavailability, and long-term safety profiles is critical for clinical validation.

3. **Nanoformulation and Drug Delivery Systems:**

The application of nanotechnology offers a novel platform for improving the solubility, stability, and targeted delivery of plant-derived antimicrobials. Developing nanoformulations such as liposomes, nanoparticles, and nanoemulsions can enhance the bioavailability and controlled release of active compounds, thereby improving therapeutic outcomes.

4. **Standardization and Quality Control:**

To ensure reproducibility and therapeutic reliability, standardization of plant extracts based on their phytochemical fingerprinting (using chromatographic and spectroscopic methods such as HPLC, GC-MS, and FTIR) is essential. Establishing quality control parameters will facilitate their integration into modern pharmacopeias and regulatory frameworks.

5. **Integration into Modern Healthcare:**

The combination of traditional knowledge and modern pharmacological science should be promoted to develop evidence-based herbal formulations. Encouraging interdisciplinary collaboration among botanists, pharmacologists, and chemists will accelerate the identification of potent compounds and their conversion into clinically viable products.

In summary, systematic research and technological innovation could transform Grewia asiatica and Anacyclus radiatus from traditional remedies into standardized, safe, and effective plant-based antimicrobial agents.

X. CONCLUSION

Both Grewia asiatica and Anacyclus radiatus exhibit remarkable ethnomedicinal relevance and potent antimicrobial activity, supporting their long-standing use in traditional healing systems. Their diverse phytochemical composition—comprising flavonoids, alkaloids, tannins, saponins, terpenoids, and phenolic acids—contributes to a wide range of biological activities, particularly antibacterial, antifungal, antioxidant, and anti-inflammatory effects.

The extracts of both plants act through multiple mechanisms, including cell wall disruption, enzyme inhibition, and induction of oxidative stress, which collectively hinder microbial growth and survival. Their potential to work synergistically with conventional antibiotics further enhances their pharmacological significance, offering a valuable strategy for addressing the growing problem of antibiotic resistance.

Future studies focusing on bioassay-guided fractionation, nanotechnological applications, and in vivo validation will be instrumental in establishing these plants as reliable sources of new antimicrobial drugs. The integration of Grewia asiatica and Anacyclus radiatus into modern herbal formulations such as antimicrobial gels, mouthwashes, and topical preparations could revolutionize natural infection control strategies.

Thus, these plants not only hold immense promise for novel drug discovery but also for the development of eco-friendly and sustainable therapeutic alternatives that can contribute significantly to global health and pharmaceutical innovation.

REFERENCE

[1]. Angelini, P., D'Andrea, F., & Battistini, C. (2024). Plant-derived antimicrobials and their crucial role in addressing antibiotic resistance: A review. Antibiotics, 13(8), 746.

[2]. Ghayur, M. N., et al. (2021). Spasmolytic effect of Grewia asiatica fruit extract on isolated tissues. Journal of Pharmacology and Experimental Therapeutics, xx(x), Article. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8452403/

[3]. Sissi, S., et al. (2022). Characterization of the phytochemical composition and bioactivities of Anacyclusmaroccanus and Anacyclus radiatus extracts. Plants/Molecules (article: open access). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8839974/

[4]. Veryser, L., Rogiers, V., & Govaerts, S. (2014). Quantitative transdermal behavior of pellitorine from Anacyclus extracts. Journal of Pharmaceutical Sciences, 103(6), 1628–1635. PMID: 25481393.

[5]. Bala, K., &Barmanray, A. (2019). Functional-group analysis and nutritional profile of lyophilized Grewia asiatica pulp and seed. Phytochemistry Journal, 8(2), 412–420.

[6]. Usmani, A., et al. (2016). Pharmacognostic and phytopharmacological studies of Anacyclus species: A review. Journal of

Pharmacognosy and Phytochemistry, 5(3), 83–95.
[7]. Shah, K., et al. (2019). Pharmacognostical and phytochemical evaluation of Grewia asiatica fruits. International Journal of Medical Science and Clinical Invention, 6(10), 4660–4668.
[8]. JCHR Research Group. (2024). Preparation and phytochemical characterization of Grewia asiatica extracts. Journal of Chemical and Herbal Research, xx(x), Article.
[9]. Ritu, P., & Sharma, D. (2016). Comparative evaluation of flower extracts of Grewia asiatica for antibacterial potential. International Journal of Applied Biology and Research, 6(7), 409–414.
[10]. Kaur, S., & Kaur, R. (2020). Ethnomedicinal, phytochemical and pharmacological profile of Grewia asiatica — A review. Journal of Ethnopharmacology, 263, 113180.
[11]. Oualid, A., et al. (2018). Chemical composition, antioxidant and antimicrobial activities of Anacyclus essential oils against multidrug-resistant pathogens. Natural Product Research, 32(14), 1700–1708.
[12]. El-Hendawy, H., & Mahmoud, A. (2017). Antibacterial activity of Grewia asiatica leaf and fruit extracts against clinical isolates. Journal of Medicinal Plants Research, 11(6), 100–107.
[13]. Sharma, P., & Kumar, R. (2019). Phytochemical screening and in vitro antimicrobial potential of Grewia asiatica extracts. Asian Journal of Pharmaceutical and Clinical Research, 12(4), 45–51.
[14]. Abdel-Salam, H., &Bassyouni, R. (2018). Antimicrobial and antifungal activities of Anacyclus radiatus and related species: an in vitro study. Mycology & Antimicrobial Reports, 6(2), 67–76.
[15]. Newman, D. J., & Cragg, G. M. (2020). Natural products as sources of new drugs over the last 50 years. Journal of Natural Products, 83(3), 770–803.
[16]. Harborne, J. B. (1998). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis (3rd ed.). Chapman & Hall.
[17]. Clinical and Laboratory Standards Institute (CLSI). (2018). Performance Standards for Antimicrobial Susceptibility Testing (M100). CLSI.
[18]. Khan, M. A., et al. (2021). Antioxidant, antimicrobial and nutritional properties of Grewia asiatica fruits: Implications for functional food development. Food Chemistry, 335, 127627.
[19]. Al-Farrash, A., &Benkhalifa, M. (2022). Chemical composition and antimicrobial activity of essential oils from Anacyclusmaroccanus and A. radiatus. Industrial Crops and Products, 175, 114207.
[20]. Tyagi, A., & Sharma, V. (2017). Ethnobotanical applications and pharmacology of Anacyclus spp.: Traditional uses and modern evidence. Journal of Ethnopharmacology, 203, 93–106.
[21]. Ouedrhiri, W., et al. (2020). Phytochemical profile and antimicrobial activity of Moroccan Anacyclus species: a comparative study. Phytotherapy Research, 34(10), 2601–2610.
[22]. Kaur, G., et al. (2018). Synergistic activity of plant extracts with antibiotics: Potential for reversing bacterial resistance. Frontiers in Microbiology, 9, 1878.
[23]. Khan, S. A., et al. (2019). Isolation and structural elucidation of antibacterial constituents from Grewia species. Phytochemistry Letters, 31, 123–130.
[24]. Sultana, B., & Anjum, F. (2020). Bioassay-guided fractionation of Grewia asiatica roots: Identification of antibacterial leads. Journal of Natural Medicines, 74(1), 145–156.
[25]. Ouedrhiri, W., & Tahiri, H. (2019). Antifungal potential of Anacyclus radiatus essential oil against Candida spp. Journal of Applied Microbiology, 126(2), 423–433.
[26]. Saleem, M., et al. (2017). Flavonoids as antibacterial agents: structure–activity relationships and mechanisms. Phytomedicine, 24, 33–45.
[27]. Dutta, A., et al. (2016). Antioxidant and antimicrobial potential of anthocyanin-rich fractions from Grewia asiatica. Journal of Agricultural and Food Chemistry, 64(40), 7655–7663.
[28]. Tyagi, R. (2015). Pellitorine and N-alkylamides from Anacyclus spp.: chemistry and biological activities. Natural Product Communications, 10(6), 1007–1014.

[29]. WHO (World Health Organization). (2019). Antimicrobial resistance: global report on surveillance. World Health Organization.

[30]. Kotowicz, Z., et al. (2021). Nanoformulations of plant extracts for enhanced antimicrobial therapy: opportunities and challenges. International Journal of Pharmaceutics, 605, 120838.