

A Review On Phytochemical And Therapeutic Potential Of *Piper Betel* For Antioxidant Activity

M. Mumtaj Begum*, M.L. Indhumathi, E. Anbuselvam, Mohamed Nibil V.,
SanjaiTamil A., Sreerenjini K. S, Hariharan

Sree Abirami College of Pharmacy, Eachanari, Coimbatore – 641 021, TamilNadu, India

ABSTRACT

Piper betel L., commonly known as betel leaf, is a medicinal plant widely used in traditional systems such as Ayurveda, Siddha, and Unani due to its broad therapeutic potential. Recent scientific interest has emphasized its phytochemical composition and pharmacological properties, particularly its antioxidant activity. The plant contains diverse bioactive compounds, including phenolics, flavonoids, alkaloids, tannins, terpenoids, steroids, and essential oils. Major constituents such as hydroxychavicol, eugenol, chavicol, chavibetol, and allylpyrocatechol are largely responsible for its biological effects. Oxidative stress, resulting from excessive reactive oxygen species and weakened antioxidant defenses, contributes to many chronic diseases. Studies have shown that Piper betel extracts possess strong free radical scavenging ability, reduce lipid peroxidation, and enhance endogenous antioxidant enzymes like superoxide dismutase, catalase, and glutathione peroxidase. These properties help protect against oxidative damage and related conditions, including inflammation, diabetes, cardiovascular diseases, neurodegenerative disorders, and cancer. In addition to its antioxidant effects, Piper betel exhibits antimicrobial, anti-inflammatory, hepatoprotective, antidiabetic, and anticancer activities, reinforcing its medicinal value. However, despite promising preclinical evidence, limited clinical studies and lack of standardized extraction methods remain challenges. Overall, Piper betel represents a valuable natural source of antioxidants with significant potential for pharmaceutical and nutraceutical applications.

Keywords: Piper betel; antioxidant activity; phytochemicals; phenolic compounds; reactive oxygen species; oxidative stress; free radical scavenging; therapeutic potential; medicinal plants.

INTRODUCTION

Medicinal plants have long served as a cornerstone of traditional healthcare systems worldwide, providing a rich source of bioactive compounds for the prevention and treatment of various diseases. In recent decades, increasing scientific attention has been directed toward plant-derived antioxidants due to their potential to combat oxidative stress-related disorders. Oxidative stress arises from an imbalance between the generation of reactive oxygen species (ROS) and the body's antioxidant defense mechanisms, leading to cellular damage, lipid peroxidation, protein modification, and DNA instability. This condition has been strongly associated with the pathogenesis of chronic diseases such as diabetes mellitus, cardiovascular diseases, neurodegenerative disorders, cancer, and inflammatory conditions. Consequently, the exploration of natural antioxidants from medicinal

plants has become a major area of research in pharmacology and biomedical sciences^[1,2].

Piper betel L., commonly known as betel leaf, belongs to the family Piperaceae and is widely cultivated in South and Southeast Asia, particularly in India, Sri Lanka, Malaysia, Thailand, and Indonesia. Traditionally, betel leaves have been used not only as a masticatory but also as a therapeutic agent in Ayurveda, Siddha, and Unani systems of medicine. The leaves are valued for their carminative, stimulant, antiseptic, and anti-inflammatory properties and are commonly used in the management of cough, indigestion, wounds, oral infections, and respiratory ailments.

Phytochemical investigations of *Piper betel* have revealed a diverse array of bioactive constituents, including phenolic compounds, flavonoids, alkaloids, tannins, terpenoids, saponins, and essential oils.

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Among these, phenolic compounds such as hydroxychavicol, eugenol, chavicol, and chavibetol are recognized for their strong antioxidant properties. These compounds exert their effects by scavenging free radicals, chelating metal ions, inhibiting lipid peroxidation, and enhancing endogenous antioxidant enzyme systems. Experimental studies have demonstrated significant free radical scavenging activity of *Piper betel* extracts in various in vitro assays such as DPPH, ABTS, and FRAP methods, as well as protective effects in animal models subjected to oxidative stress.

In addition to antioxidant activity, *Piper betel* exhibits multiple pharmacological properties, including antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, cardioprotective, and anticancer effects. These therapeutic potentials are closely linked to its ability to modulate oxidative pathways and inflammatory mediators. However, despite extensive preclinical research, clinical validation remains limited, and issues related to standardization, dosage optimization, and long-term safety require further investigation^[3].

Given the growing interest in natural antioxidants and the rich phytochemical composition of *Piper betel*, a comprehensive review of its phytochemical profile and therapeutic potential, particularly concerning antioxidant activity, is timely and relevant. This review aims to synthesize current scientific evidence, highlight key bioactive compounds responsible for antioxidant effects, and discuss future prospects for its development in pharmaceutical and nutraceutical applications.



Figure 1 : Leaves of *Piper betel*

PHYTOCHEMICAL POTENTIAL OF PIPER BETEL

Piper betel L. (family Piperaceae) is a perennial dioecious climber that has been extensively cultivated and traditionally utilized across South and Southeast Asia for its medicinal, cultural, and economic importance. The plant thrives in warm, humid climatic conditions and is typically propagated vegetatively, ensuring preservation of desirable phytochemical traits across cultivars. Its heart-shaped, glossy leaves are aromatic and contain a wide spectrum of secondary metabolites that contribute to its therapeutic versatility. Historically, the leaves have been incorporated into traditional systems of medicine such as Ayurveda, Siddha, and Unani for the management of digestive disorders, respiratory ailments, wound healing, and oral health maintenance.

Although the **leaves** are the most extensively studied and pharmacologically exploited part of the plant due to their high concentration of phenolic compounds and essential oils, recent phytochemical investigations have revealed that other plant parts also possess noteworthy bioactive constituents. The **stems** contain appreciable amounts of phenolics, lignans, and terpenoid derivatives that may contribute to moderate antioxidant and antimicrobial activities, supporting their traditional use in certain folk remedies. Similarly, the **roots** have been found to contain alkaloids, steroidal compounds, and minor phenolic fractions that exhibit potential antimicrobial and protective effects, although they remain comparatively underexplored in scientific literature^[5-7].

The **essential oils**, primarily extracted from the leaves but also present in small quantities in other aerial parts, are particularly rich in volatile phenolic compounds such as eugenol, chavicol, and chavibetol, which are largely responsible for the plant's characteristic aroma and significant biological activities. These volatile constituents play a crucial role in membrane stabilization, microbial inhibition, and free radical scavenging mechanisms. Furthermore, variations in phytochemical composition among different plant parts are influenced by geographical origin, soil composition, climatic conditions, harvesting stage, and extraction

methods, all of which can significantly affect therapeutic efficacy.

➤ Leaves

The leaves of *Piper betel* are the primary source of bioactive phytochemicals. Phytochemical screening has identified:

- Phenolic compounds – hydroxychavicol, chavicol, chavibetol
- Flavonoids – quercetin, catechin
- Alkaloids
- Tannins
- Saponins
- Terpenoids
- Steroids
- Essential oils (rich in eugenol and other aromatic compounds)

Among these, hydroxychavicol and eugenol are major active constituents responsible for strong antioxidant, antimicrobial, anti-inflammatory, and anticancer activities. The high phenolic content contributes significantly to free radical scavenging and inhibition of lipid peroxidation.

➤ Stems

Although less studied than leaves, the stems contain: Phenolic compounds, Lignans, Alkaloids, Terpenoids. Stem extracts have demonstrated moderate antioxidant and antimicrobial properties.

Some studies suggest that stem constituents contribute to anti-inflammatory and wound-healing effects, supporting traditional medicinal applications.

➤ Roots

The roots of *Piper betel* contain: Alkaloids, Phenolic compounds, Steroidal compounds, Volatile constituents. Root extracts are traditionally used for respiratory disorders and digestive issues. Preliminary studies indicate potential antimicrobial and antioxidant activity, though detailed phytochemical characterization remains limited compared to leaves.

➤ Essential Oil (Leaf Oil)

The essential oil extracted from leaves is particularly rich in: Eugenol, Chavicol, Chavibetol, Allylpyrocatechol, Caryophyllene. These volatile compounds are responsible for the characteristic aroma and significant biological activities such as antioxidant, antifungal, antibacterial, and anti-inflammatory effects. The composition of essential oil may vary depending on geographical location and cultivar.

➤ Other Plant Components

- **Petiole and inflorescence:** Limited studies indicate presence of phenolics and volatile compounds.
- **Whole plant extracts:** Show synergistic effects due to combined phytoconstituents.

Table 1: Phytochemical constituents of Piper betel

Plant Part	Major Phytochemical Constituents	Representative Compounds
Leaves	Phenolic compounds, Flavonoids, Alkaloids, Tannins, Saponins, Terpenoids, Steroids, Essential oils	Hydroxychavicol, Eugenol, Chavicol, Chavibetol, Allylpyrocatechol, Quercetin, Catechin
Leaf Essential Oil	Volatile phenols, Terpenes, Sesquiterpenes	Eugenol, Chavicol, Chavibetol, Caryophyllene, Safrole (trace in some varieties)
Stems	Phenolics, Alkaloids, Lignans, Terpenoids	Chavicol derivatives, Piperine-like alkaloids (reported in trace), β -caryophyllene
Roots	Alkaloids, Phenolic compounds, Steroidal compounds, Volatile constituents	Phenolic acids, Steroidal fractions (reported), Minor alkaloids
Petiole	Phenolics, Flavonoids	Chavicol-related compounds (reported in minor quantity)

Plant Part	Major Phytochemical Constituents	Representative Compounds
Inflorescence	Volatile compounds, Phenolic derivatives	Essential oil components similar to leaf (lower concentration)

➤ Phenolic Compounds

Phenolic compounds are the most abundant bioactive constituents in *Piper betel*. They are primarily responsible for its strong antioxidant activity by donating hydrogen atoms to neutralize free radicals and preventing oxidative stress. Key phenolics such as hydroxychavicol and chavicol contribute to antimicrobial and anti-inflammatory effects.

➤ Flavonoids

Flavonoids are natural polyphenolic compounds known for their antioxidant and anti-inflammatory properties. They help in scavenging reactive oxygen species (ROS) and protecting cells from oxidative damage. Flavonoids like quercetin and catechin also exhibit cardioprotective and anticancer potential.

➤ Alkaloids

Alkaloids are nitrogen-containing compounds that often possess significant pharmacological activities. In *Piper betel*, they contribute to antimicrobial and analgesic properties. Some alkaloids may also support anti-inflammatory and therapeutic effects.

➤ Tannins

Tannins are polyphenolic compounds with strong antioxidant and antimicrobial properties. They help in wound healing by forming protective layers over tissues and reducing inflammation. Tannins also inhibit lipid peroxidation and microbial growth.

➤ Saponins

Saponins are glycosidic compounds known for their surface-active properties. They exhibit antioxidant, immune-boosting, and cholesterol-lowering effects. Additionally, saponins contribute to antimicrobial and anti-inflammatory activities.

➤ Terpenoids

Terpenoids are a large class of naturally occurring organic chemicals derived from isoprene units. They

play an important role in antioxidant and anti-inflammatory responses. Some terpenoids present in *Piper betel* also demonstrate antimicrobial and anticancer activities.

➤ Steroids (Phytosterols)

Plant steroids, or phytosterols, contribute to anti-inflammatory and membrane-stabilizing properties. They may help in regulating cholesterol levels and improving cardiovascular health. These compounds also support overall cellular protection.

➤ Essential Oils

Essential oils are volatile aromatic compounds responsible for the characteristic aroma of *Piper betel*. They contain bioactive molecules such as eugenol and chavibetol, which possess strong antioxidant, antibacterial, and antifungal properties. The essential oil fraction significantly enhances the plant's therapeutic potential^[10-13].

MEDICINAL PROPERTIES OF PIPER BETEL

The leaves of *Piper betel* have occupied a prominent position in traditional medicine for centuries due to their remarkable therapeutic versatility and rich reservoir of biologically active phytochemicals. These medicinal properties are primarily attributed to phenolic compounds, flavonoids, essential oils, and other secondary metabolites that exert synergistic pharmacological effects. Modern scientific investigations increasingly validate many of the traditional claims, highlighting the plant's potential as a natural therapeutic agent.

The phytochemical richness of the leaves is largely influenced by their stage of maturity, as both tender and ripe leaves undergo dynamic biochemical changes during growth and development. Tender leaves are physiologically more active and tend to synthesize higher amounts of protective polyphenols and flavonoids, which serve as defense molecules against environmental stressors such as ultraviolet radiation, pathogens, and oxidative damage. This

elevated concentration of phenolic antioxidants often results in stronger radical scavenging capacity and higher total antioxidant potential in young leaves.

In contrast, ripe or mature leaves generally accumulate greater quantities of essential oils and volatile aromatic compounds, including eugenol, chavicol, and chavibetol, which contribute significantly to antimicrobial, anti-inflammatory, and preservative properties. As the leaf matures, secondary metabolite pathways become more stabilized, leading to increased storage of lipophilic constituents in oil glands. Although the total flavonoid concentration may slightly decline with maturity due to structural tissue development, the enhanced essential oil content in ripe leaves often provides stronger antimicrobial efficacy and therapeutic aroma.

Therefore, both tender and mature leaves possess distinct phytochemical advantages, and their selection for medicinal or pharmaceutical applications should depend on the intended therapeutic objective, whether antioxidant enrichment or antimicrobial potency^[15,16].

❖ Antioxidant Activity

The antioxidant potential of *Piper betel* leaves is one of its most extensively studied properties, as the phenolic constituents present in the leaves efficiently neutralize free radicals by donating electrons or hydrogen atoms, thereby preventing oxidative damage to lipids, proteins, and nucleic acids. The extracts have demonstrated significant activity in various in vitro assays, including DPPH and ABTS radical scavenging methods, indicating their strong reducing power and metal-chelating ability. By enhancing endogenous antioxidant enzymes such as superoxide dismutase, catalase, and glutathione peroxidase, the leaves help restore redox balance within cells and protect tissues from oxidative stress-induced degeneration.

Mechanism of action: The phenolic compounds present in *Piper betel* leaves donate hydrogen atoms or electrons to neutralize reactive oxygen species (ROS), thereby terminating free radical chain reactions. They also chelate transition metal ions such as iron and copper, which catalyze oxidative reactions. Additionally, the extracts enhance endogenous antioxidant defense systems by

upregulating enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase.

Potential Applications: These mechanisms support the use of *Piper betel* in preventing oxidative stress-related disorders such as cardiovascular diseases, neurodegenerative conditions, diabetes, and cancer. The leaf extracts may also be developed into natural antioxidant supplements and nutraceutical formulations^[18].

❖ Antimicrobial and Antifungal Properties

Piper betel leaves exhibit broad-spectrum antimicrobial activity against numerous Gram-positive and Gram-negative bacteria, as well as pathogenic fungi, due to the presence of bioactive compounds that disrupt microbial cell membranes and inhibit essential metabolic pathways. The essential oil fraction, rich in aromatic phenols, penetrates microbial cell walls and alters membrane permeability, ultimately leading to cell death. These properties make the leaves particularly effective in managing oral infections, respiratory tract infections, and skin-related microbial conditions.

Mechanism of Action: Bioactive compounds such as phenols and essential oils disrupt microbial cell membrane integrity, increase membrane permeability, and interfere with intracellular enzymatic systems. This leads to leakage of cellular contents and inhibition of microbial growth and replication.

Potential Applications: The antimicrobial properties can be utilized in oral care products, wound healing formulations, and topical antiseptics. They may also serve as natural food preservatives to inhibit microbial contamination.

❖ Anti-inflammatory and Analgesic Effects

The anti-inflammatory activity of the leaves is mediated through the inhibition of inflammatory mediators such as prostaglandins, leukotrienes, and pro-inflammatory cytokines, which play crucial roles in the development of pain and tissue swelling. By suppressing these mediators, the leaf extracts reduce edema and alleviate discomfort associated with inflammatory disorders. Additionally, their mild analgesic action contributes to pain relief, especially

in conditions such as arthritis, headaches, and minor injuries.

Mechanism of Action: The leaf extracts inhibit cyclooxygenase (COX) and lipoxygenase (LOX) pathways, thereby reducing the synthesis of inflammatory mediators such as prostaglandins and leukotrienes. They also suppress pro-inflammatory cytokines and oxidative stress-induced inflammatory signaling pathways.

Potential Applications: These effects suggest potential applications in managing arthritis, respiratory inflammation, muscle pain, and minor injuries. The plant may be explored for developing herbal anti-inflammatory and pain-relief formulations.

❖ Anticancer and Chemopreventive Potential

Emerging research suggests that certain phytoconstituents in *Piper betel* leaves may exert anticancer effects by modulating cellular signaling pathways, inducing apoptosis in abnormal cells, and inhibiting uncontrolled cell proliferation. The antioxidant capacity of the leaves further contributes to cancer prevention by minimizing DNA damage caused by oxidative stress. Although promising results have been obtained in laboratory and animal studies, comprehensive clinical investigations are necessary to confirm their safety and therapeutic efficacy in humans.

Mechanism of Action: Certain phytochemicals induce apoptosis (programmed cell death) in abnormal cells by activating caspase enzymes and modulating mitochondrial pathways. They also inhibit tumor cell proliferation by regulating cell cycle checkpoints and suppressing oxidative DNA damage.

Potential Applications: *Piper betel* may serve as a complementary therapeutic agent in cancer prevention strategies. Its compounds could be investigated for inclusion in chemopreventive drugs or functional foods aimed at reducing cancer risk^[19,20].

❖ Antidiabetic and Metabolic Benefits

The hypoglycemic activity of *Piper betel* leaves has been observed in experimental models, where the extracts help lower blood glucose levels by improving insulin sensitivity and reducing oxidative stress in

pancreatic tissues. The bioactive compounds may enhance glucose uptake in peripheral tissues and inhibit carbohydrate-digesting enzymes, thereby regulating postprandial blood sugar levels. These effects highlight the potential role of the leaves in managing diabetes and metabolic syndrome.

Mechanism of Action: The leaf extracts improve insulin sensitivity and enhance glucose uptake in peripheral tissues. They may inhibit carbohydrate-digesting enzymes such as α -amylase and α -glucosidase, reducing postprandial hyperglycemia, while also protecting pancreatic β -cells from oxidative stress.

Potential Applications: These properties indicate potential use in the management of type 2 diabetes mellitus and metabolic syndrome. Herbal antidiabetic formulations incorporating *Piper betel* could help regulate blood glucose levels naturally.

❖ Gastroprotective and Digestive Stimulant Action

Traditionally used as a digestive stimulant, betel leaves promote salivary secretion and stimulate digestive enzymes, which facilitate proper digestion and nutrient absorption. Their carminative properties help relieve flatulence, bloating, and indigestion, while their protective effect on the gastric mucosa reduces the risk of ulcer formation. The antimicrobial action also assists in controlling harmful gut microorganisms, thereby supporting overall gastrointestinal health.

Mechanism of Action: The bioactive constituents stimulate salivary and gastric secretions, enhance digestive enzyme activity, and protect the gastric mucosa by reducing oxidative damage and inflammation. Their antimicrobial properties also help maintain gut microbial balance.

Potential Applications: The leaves can be used in treating indigestion, flatulence, gastritis, and gastric ulcers. They may also be incorporated into herbal digestive tonics and gastrointestinal protective supplements.

❖ Hepatoprotective Effects

The hepatoprotective potential of *Piper betel* leaves is closely linked to their antioxidant and anti-

inflammatory activities, which collectively protect liver cells from toxin-induced damage and oxidative stress. By reducing lipid peroxidation and stabilizing cellular membranes, the extracts help maintain normal liver enzyme levels and support detoxification functions. These properties suggest their possible application in preventing liver disorders caused by chemical exposure or metabolic imbalance.

Mechanism of Action: The antioxidant compounds reduce lipid peroxidation in hepatic tissues and stabilize cellular membranes, thereby preventing toxin-induced liver damage. They also enhance detoxification enzymes and reduce inflammatory responses within the liver.

Potential Applications: These effects support potential applications in preventing drug-induced liver injury, alcohol-related liver damage, and other hepatic disorders. Herbal liver-protective formulations may benefit from inclusion of *Piper betel* extracts^[21].

❖ Cardioprotective Activity

Through the modulation of lipid metabolism and oxidative pathways, *Piper betel* leaves may help reduce serum cholesterol levels and prevent oxidative modification of low-density lipoproteins, which is a key factor in atherosclerosis development. The antioxidant activity contributes to improved vascular function and reduced risk of cardiovascular complications. These combined effects underline the cardioprotective potential of the leaf extracts.

Mechanism of Action: The leaf extracts reduce oxidative stress in vascular tissues, inhibit LDL oxidation, and improve lipid metabolism. They may also enhance endothelial function by modulating nitric oxide availability.

Potential Applications: These mechanisms suggest possible use in preventing atherosclerosis, hypertension, and other cardiovascular disorders. The plant may be developed into heart-health nutraceuticals.

❖ Wound Healing and Dermatological Applications

The wound-healing properties of *Piper betel* leaves are attributed to their antimicrobial, anti-

inflammatory, and antioxidant activities, which accelerate tissue repair and prevent secondary infections. The extracts promote collagen synthesis and enhance tissue regeneration, leading to faster wound contraction and improved healing outcomes. Traditionally, crushed leaves have been applied topically to treat cuts, burns, and skin infections^[22].

Mechanism of Action: The antimicrobial activity prevents infection at wound sites, while antioxidant and anti-inflammatory effects accelerate tissue repair. The extracts stimulate collagen synthesis and promote faster epithelialization.

Potential Applications: *Piper betel* leaves can be incorporated into topical ointments, gels, and wound dressings to enhance healing of cuts, burns, and ulcers.

CONCLUSION

Piper betel L. is a phytochemically rich medicinal plant with notable antioxidant potential, primarily due to bioactive compounds such as phenolics and essential oils. Its ability to scavenge free radicals and enhance endogenous antioxidant enzymes supports its role in reducing oxidative stress and preventing chronic diseases, including diabetes, cardiovascular and neurodegenerative disorders, and cancer. Additionally, its antimicrobial, anti-inflammatory, and hepatoprotective properties further strengthen its therapeutic value. However, despite promising preclinical evidence, limited clinical studies and lack of standardized extraction methods highlight the need for further research. Overall, *Piper betel* holds significant potential as a natural source for antioxidant-based pharmaceutical and nutraceutical applications.

REFERENCES

1. Biswas P, Anand U, Saha SC, Kant N, Mishra T, Masih H, Bar A, Pandey DK, Jha NK, Majumder M, Das N. Betelvine (*Piper betel* L.): A comprehensive insight into its ethnopharmacology, phytochemistry, and pharmacological, biomedical and therapeutic attributes. *Journal of cellular and molecular medicine*. 2022 Jun;26(11):3083-119.
2. Sakinah D, Rusdi MS. Review of traditional use, phytochemical and pharmacological activity of

- Piper betel L. *Galore International Journal of Health Sciences and Research*. 2020 Jul;5(3):59-66.
3. Shah SK, Garg G, Jhade D, Patel N. Piper betel: phytochemical, pharmacological and nutritional value in health management. *Int. J. Pharm. Sci. Rev. Res.* 2016 May;38(2):181-9.
4. Peddapalli H, Boggula N, Ramya D, Rashi KN, Rao PV. Therapeutic potential of Piper betel: an amazing nature's medicinal reservoir. *Chem. Res. J.* 2020;5:62-75.
5. Al-Gburi AS, Mustafa KK, Ullah S, Khan A, Qayum U, Al Touby SS, Manickam B, Rehman NU, Al-Harrasi A, Weli AM. Phytochemical, Antioxidant, Cytotoxic, Antibacterial Activity, and Enzymatic Inhibition Study of Piper Betel Leaves. *Iranian Journal of Pharmaceutical Sciences*. 2024 Apr 1;20(2):115-29.
6. Carsono N, Tumilaar SG, Kurnia D, Latipudin D, Satari MH. A review of bioactive compounds and antioxidant activity properties of piper species. *Molecules*. 2022 Oct 10;27(19):6774.
7. Chavhan M, Sharma S, Tiwari H. Unlocking the therapeutic potential of piper betel: an in-depth exploration of its health benefits. *International Journal of Biology, Pharmacy and Allied Science*. 2025;14(5):2455-61.
8. Sarma C, Rasane P, Kaur S, Singh J, Singh J, Gat Y, Garba U, Kaur D, Dhawan K. Antioxidant and antimicrobial potential of selected varieties of Piper betel L.(Betel leaf). *Anais da Academia Brasileira de Ciências*. 2018 Oct 18;90:3871-8.
9. Basit MA, Kadir AA, Chwen LT, Salleh A, Kaka U, Idris SB, Farooq AA, Javid MA, Murtaza S. Qualitative and quantitative phytochemical analysis, antioxidant activity and antimicrobial potential of selected herbs Piper betel and *Persicaria odorata* leaf extracts.
10. Alam B, Majumder R, Akter S, Lee SH. Piper betel extracts exhibit antitumor activity by augmenting antioxidant potential. *Oncology letters*. 2015 Feb 1;9(2):863-8.
11. Alam B, Akter F, Parvin N, Pia RS, Akter S, Chowdhury J, Sifath-E-Jahan K, Haque E. Antioxidant, analgesic and anti-inflammatory activities of the methanolic extract of Piper betel leaves. *Avicenna journal of phytomedicine*. 2013;3(2):112.
12. Nayaka NM, Sasadara MM, Sanjaya DA, Yuda PE, Dewi NL, Cahyaningsih E, Hartati R. Piper betel (L): Recent review of antibacterial and antifungal properties, safety profiles, and commercial applications. *Molecules*. 2021 Apr 16;26(8):2321.
13. Vikash C, Shalini T, Verma NK, Singh DP, Chaudhary SK, Asha R. Piper betel Phytochemistry, traditional use & pharmacological activity a review. *Int J Pharm Res Dev*. 2012;4(4):216-23.
14. Salehi B, Zakaria ZA, Gyawali R, Ibrahim SA, Rajkovic J, Shinwari ZK, Khan T, Sharifi-Rad J, Ozleyen A, Turkdonmez E, Valussi M. Piper species: A comprehensive review on their phytochemistry, biological activities and applications. *Molecules*. 2019 Apr 7;24(7):1364.
15. Vikrama Chakravarthi P, Murugesan S, Arivuchelvan A, Sukumar K, Arulmozhi A, Jagadeeswaran A. Therapeutic antigout and antioxidant activity of Piper betel L. in gout-induced broilers. *British poultry science*. 2022 May 4;63(3):324-31.
16. Karak S, Das S, Biswas M, Choudhury A, Dutta M, Chaudhury K, De B. Phytochemical composition, β -glucuronidase inhibition, and antioxidant properties of two fractions of Piper betel leaf aqueous extract. *Journal of Food Biochemistry*. 2019 Dec;43(12):e13048.
17. Poudel M, Koirala N, Mehta RK, Lamsal A. Estimation of phytochemical constituents and evaluation of antioxidant potency of Piper betel leaves. *Nepal Journal of Biotechnology*. 2024 Jul 31;12(1):48-57.
18. Azahar NI, Mokhtar NM, Arifin MA. Piper betel: a review on its bioactive compounds, pharmacological properties, and extraction process. *InIOP Conference Series: Materials Science and Engineering* 2020 Dec 1 (Vol. 991, No. 1, p. 012044). IOP Publishing.
19. Tarmale VA, Wankhede S, Sen AK, Uppalwar SV. Pharmacological Properties, and Traditional Applications of Betel Leaf (Piper betel L.). *Journal of Pharma Insights and Research*. 2024 Dec 5;2(6):131-41.
20. Savsani H, Srivastava A, Gupta S, Patel K. Strengthening antioxidant defense & cardio protection by Piper betel: An in-vitro study. *Heliyon*. 2020 Jan 1;6(1).

21. Desriani N, Arif M, Putri NS, Nabilla S, Savitri A, Salsabila A, Arizal SP. Traditional Uses and Pharmacology Study of Piper betel L.: A Systematic Review. Journal of Ethnoscience and Educational Studies. 2025 Aug 31;1(2):68-80.
22. Das S, Parida R, Sandeep IS, Nayak S, Mohanty S. Biotechnological intervention in betelvine (Piper betel L.): A review on recent advances and future prospects. Asian Pacific Journal of Tropical Medicine. 2016 Oct

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