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FROM FOLK MEDICINE TO FUTURE PHARMACEUTICALS: A CRITICAL REVIEW OF PLECTRANTHUS AMBOINICUS MEDICINAL USES AND SCIENTIFIC VALIDATION

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Abstract:

Plectranthus amboinicus (Lour.) Spreng, Indian Borage or Country Borage, is a Lamiaceae family perennial herb with wide awareness for its aromatic nature and immense ethnobotanical value. Traditionally used by example in various cultures for its medicinal usage, the present review summarizes available information on its botanical description, diversified traditional usage, dense phytochemical content, and established pharmacological activities.

P. amboinicus is traditionally used in traditional medicine to treat various disorders such as respiratory ailments like asthma and cough, inflammatory disorders like rheumatoid arthritis, skin infections, fever, and gastrointestinal disease. Contemporary scientific studies have all but validated these traditional applications since P. amboinicus has shown bountiful phytochemical composition like flavonoids, phenols, terpenes, and various other bioactive molecules. These constituents are mainly responsible for the plant's purported pharmacological activities, including potent antimicrobial, anti-fungal, anti-inflammatory, antioxidant, antidiabetic, anxiolytic, anti-neoplastic, analgesic, and wound-healing activities.This review emphasizes the therapeutic potential of P. amboinicus, bridging traditional knowledge with existing scientific evidence. It attempts to be an eclectic repository for scientists, leading future research to more accurately describe its action mechanisms, discover new drugs of therapy, and investigate its wider use in the pharmaceutical and medical industry.

Keywords: Plectranthus amboinicus, Indian Borage, Country Borage, Lamiaceae, Traditional uses, Phytochemistry, Pharmacological activities, Bioactive compounds, Therapeutic potential, Plant extract.

1. Introduction

Medicinal plants have traditionally been the cornerstone of indigenous healthcare systems worldwide, offering affordable and culturally accepted remedies for a large variety of human diseases. In times when the quest for new drugs from natural products is regaining pace, the knowledge and verification of traditional usages of these plants becomes the top priority. The genus *Plectranthus* is part of the large Lamiaceae family and is widely recognized by its many variable species with very interesting aromatic and medicinal properties. Amongst them, *Plectranthus amboinicus* (Lour.) Spreng is

specially well known due to its widespread traditional application and increasing scientific confirmation.

Often referred to as Indian Borage, Country Borage, or "Karpuravalli" in Tamil, *P. amboinicus* is a highly valued herb in various ethnomedicinal practices. Its pungent, aromatic leaves have been employed for centuries to treat a range of conditions, from common colds and coughs to more complex inflammatory and infectious diseases.

This review goes in-depth on all the research available, bringing together everything we know about *Plectranthus amboinicus* – from how it appears and grows, to its incredible traditional healing potential, the natural chemicals it's full of, and how science is now verifying those advantages. Our aim is to bridge that old knowledge with contemporary research, really highlighting this plant's amazing potential for creating the drugs of the future.

1.1. Botanical Description

Plectranthus amboinicus (Lour.) Spreng, also popularly referred to as Indian Borage or Country Borage, is a succulent perennial herb with aromatic properties and is part of the Lamiaceae family. The plant has a special characteristic of growing to approximately 1 meter (3.3 feet) tall, with thicker fleshy stems that are unusually quadrangular in cross-section. Stems measuring between 30 to 90 cm (1 to 3 feet) tall may be erect or prostrate and have ascending branches.
It's typical leaves are deltoid to ovate in form, fleshy, and beset with fine pubescence, imparting a velvety feel (figure 1). They have very serrated margins and raised veins, each 5–10 cm (2–4 inches) long and 4–7 cm (1.6–2.8 inches) wide. Very aromatic leaves are oppositely directed on the stem, with short petioles. It has pale purple flowers, in a whorl on slender inflorescences that are short terminal spikes (Figure 2). Its fruit is small nutlets approximately 0.7 mm in diameter.
P. amboinicus grows in subtropical and tropical climate conditions and requires warmth, moderate rainfall, and full sun exposure. It prefers well-drained, sandy loam soils and is easily propagated by cutting stems.

Figure.1: Close-up of succulent ovate leaves with crenate margins

Figure.2: The pale purple flowers of *Plectranthus amboinicus* arranged in a whorl on a short terminal spike.

1.2. Scientific Classification

Scientific name: *Plectranthus amboinicus* (Lour.) Spreng
Kingdom: Plantae
Subkingdom: Tracheobionta – Vascular plants
Superdivision: Spermatophyta – Seed plants
Division: Magnoliopsida – Dicotyledons
Subclass: Asteridae
Order: Lamiales
Family: Lamiaceae – Mint family
Genus: *Plectranthus*
Species: *Plectranthus amboinicus* (Lour.) Spreng
Synonyms: *Coleus amboinicus*, *Plectranthus aromaticus*, Indian borage, country borage, Cuban oregano, Mexican mint, Spanish thyme

1.3. General Description

English Name: Indian Borage, Country Borage
Kannada Name: Doddapatre
Telugu Name: Karpuravalli
Tamil Name: Karpuravalli
Malayalam Name: Panikoorka
Hindi Name: Pattharchur, Ajwain Patta
Parts Used: Leaves, stems, occasionally roots and flowers

2. Traditional Uses

Across diverse cultures, *Plectranthus amboinicus* has been utilized medicinally traditionally, predominantly because of its effectiveness to treat a wide range of ailments. It is used extensively in India, particularly in Ayurvedic and Siddha medicine, where its leaves are highly valued for their medicinal properties [24,10]. Its leaves, typically consumed raw or as decoctions, are applied traditionally in a variety of diseases, displaying its adaptability.

- **Respiratory Disorders:** Leaves are extensively used in managing common respiratory illnesses such as cold, cough, bronchial asthma, hiccough, and bronchitis. Their expectorant property is greatly appreciated as it relaxes airways and calms respiratory tracts [21,23,31,27].

- **Inflammatory Diseases:** a *P. amboinicus* has been traditionally employed in demonstration of anti-inflammatory effects, and therefore it is highly common traditional medicine for inflammatory ailments, general signs of swelling, and rheumatic diseases like rheumatoid arthritis [8,23,27].

- **Gastrointestinal Health:** It has been indicated for its treatment of gastrointestinal disease conditions such as stomach-ache, colic, diarrhoea, and dyspepsia and is taken generally for its carminative benefits in facilitating digestion [12,3,27].

- **Anthelmintic Activity**: It has been used therapeutically as an anthelmintic, whereby the means of action is to provoke the release of parasitic worms from the body [21,27]

- **Dermatological Applications:** In eczema, skin infections, and wound healing, the leaves are applied topically to speed up tissue repair, heal skin ailments, and ensure overall skincare [12,3,23,27].

- **Control of Fever:** The herb is applied as a febrifuge to reduce fever, e.g., malarial fever, and is typically antipyretic [21,3,27].

- **Neurological and Renal Issues:** The conventional uses also encompass headache and renal and vesical calculi issues treatment (kidney stones) [21,12,3,27]. The plant has also been utilized in treating convulsions [21,27].

- **Cardiovascular and Metabolic Well-being:** Traditionally, the plant is used for treating hypertension and is well known to exhibit a diuretic action, enhancing urine excretion [3,23,27]. It is also used in diabetes [3,27].

- **Other Traditional Applications:** The plant was also used traditionally to treat constipation and allergies [3,27]. The leaves are also traditionally consumed raw or as ingredients for flavouring or as ingredients during the preparation of traditional food [3].

3. Phytochemical Composition

The wide range of therapeutic activities of *Plectranthus amboinicus* can be counted for by its blended and diversified phytochemical content. Comprehensive analysis has found that its leaves, stems, and essential oils contain an abundance of secondary metabolites of various classes. Table 1 shows the major phytochemical classes, describing their composition and extraction methods used in their identification.

Table 1: Phytochemical Constituents of *Plectranthus amboinicus*

Compound Type	Identified Constituents	Extraction Method
Volatile oils	Carvacrol, thymol, eugenol	Steam distillation
Phenolic compounds	Caffeic acid, rosmarinic acid, gallic acid	Methanol, ethanol
Flavonoids	Luteolin, apigenin, quercetin	Ethanol extract
Terpenoids	β-sitosterol, oleanolic acid, ursolic acid	Ethyl acetate fraction
Tannins & Saponins	Present (unspecified)	Aqueous/methanol extract
Others	Ascorbic acid, glycosides, steroids	Multiple solvents

The synergistic effect of these diverse phytochemicals is likely to be the most important factor responsible for the overall activity observed in both traditional and contemporary studies. Different spectroscopic techniques have confirmed the presence of flavonoids, glycosides, phenols, tannins, and steroids [23]. The essential oil also has significant constituents responsible for its biological activity [12].

4. Pharmacological Activities and Scientific Validation

Several in vitro and in vivo studies have supported several of the ethnomedicinal applications *of Plectranthus amboinicus,* validating its high pharmacological potential. Table 2 gives a general overview of its major pharmacological activities, type of extracts investigated, suitable models, and most significant citations.

Table 2: Pharmacological Activities of *Plectranthus amboinicus*

Pharmacological Activity	Extract Type	Study Type	Target/Model	Reference
Antimicrobial	Methanol, essential oil	*In vitro*	*S.aureus*, *E.coli*, *C. albicans*	[9]
Anti-inflammatory	Ethanol, aqueous	*In vivo*	Carrageenan-induced paw edema	[14]
Antioxidant	Methanol, ethanol	*In vitro*	DPPH, ABTS, FRAP assays	[4]
Antidiabetic	Ethanol	*In vivo*	Alloxan-induced diabetic rats	[25]
Anticancer	Methanol, ethyl acetate	*In vitro*	MCF-7, HeLa, A549, KB cell lines	[7]

Wound healing	Aqueous, ointment base	*In vivo*	Incision/excision wound model	[20]
Antiepileptic	Alcoholic extract	*In vivo*	Seizure model in rodents	[6]

4.1. Anti-inflammatory Activity

Recurring studies have shown the significant anti-inflammatory activity of *P. amboinicus* extracts, justifying its long-standing use in the treatment of inflammatory diseases. As tabulated in Table 2, using varying models, i.e., carrageenan-induced paw edema, aqueous and ethanol extracts were found to inhibit inflammation significantly [14]. Notably, Chang et al.[8] provided strong evidence of its potential anti-arthritic activity. In their collagen-induced arthritis model in Lewis rats, *P. amboinicus* extract blocked the dramatic edema of the footpad and reduced signs of arthritis. This was directly brought about by the sustained inhibition of serum anti-collagen IgM and C-reactive protein (CRP) levels.

Most importantly, the production of key pro-inflammatory cytokines like TNF-α, IL-6, and IL-1β was considerably inhibited in animals treated with higher concentrations of *P. amboinicus* [8,27]. This suggests a possible anti-inflammatory and immunomodulatory effect that lies behind its anti-rheumatic effect.

4.2. Antimicrobial and Antifungal Activity

The widely documented antimicrobial activity *of P. amboinicus* justifies its use in traditional medicine to prevent infection. As indicated from Table 2, extracts and essential oil are broad-spectrum active against a wide range of pathogenic microorganisms. Chandrashekar et al.,[9] also reported antimicrobial activity of *Plectranthus amboinicus*. Mohamed et al.,[19] also authored the antibacterial activity of *P. amboinicus* leaf extracts. Rani & Khullar [26] also established the antimicrobial activity of various medicinal plants such as

P. amboinicus. Akinyemi et al. [2] authored particularly about its activity against Methicillin-Resistant Staphylococcus aureus (MRSA), a relevant clinical pathogen. Erny Sabrina M.N. et al.[12] conducted experiments in which *P. amboinicus* essential oil showed activity against nine common microorganisms such as various strains of Staphylococcus (e.g., S. epidermis, S. aureus, MRSA), Escherichia coli, Serratia marcescens, Proteus vulgaris, Bacillus subtilis, Candida albicans, and Candida tropicalis. While most of them were susceptible, Pseudomonas aeruginosa was resistant. Interestingly, the oil showed larger inhibition zones against E. coli, S. aureus, and C. tropicalis than commercial antibiotics such as streptomycin and nystatin, which proves its high activity. This broad spectrum of activity is primarily due to its high phenolic compound content such as carvacrol and thymol, which kills microbial cell membranes and inhibits their growth. Besides*, P. amboinicus* also shows promising antibiofilm activity, which is of great significance in the treatment of drug-resistant microbial infections [12,23,27].

4.3. Antioxidant Activity

P. amboinicus is recognized as a significant source of natural antioxidants, which are crucial for combating oxidative stress linked to various chronic diseases. As indicated in Table 2, studies utilizing in vitro assays such as DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis(3-

ethylbenzothiazoline-6-sulfonic acid) diammonium salt), and FRAP (ferric reducing antioxidant power) have confirmed the potent radical scavenging and reducing capabilities of its methanol and ethanol extracts [4].
Chauhan & Tripathi [11] critically evaluated *P. amboinicus* as an antioxidant, particularly. This activity is largely due to its richness in phenolic compounds such as rosmarinic acid, caffeic acid, and other flavonoids such as quercetin and luteolin, which are strong antioxidant agents [17,16,30]. These compounds effectively scavenge toxic free radicals, thereby safeguarding cellular components against oxidative damage and rendering the plant healthy in general as well as imparting its anti-allergic activity [27].

4.4. Antidiabetic Activity

The clinical efficacy of *P. amboinicus* as an agent for the treatment of diabetes has been explored, and evidence showed that it is able to regulate blood glucose levels effectively. As evident in Table 2 by Ramasamy & Saraswathy [25], ethanol extracts of *P. amboinicus* showed strong antidiabetic activity against alloxan-induced diabetic rats. The process is thought to be the inhibition of the key enzymes catalysing hydrolysis of carbohydrates, i.e., α-amylase and α-glucosidase. Inhibition of the hydrolysis of the complex carbohydrates into simple sugars in the intestine *by P. amboinicus* avoids postprandial hyperglycaemia, offering a natural means of diabetes control [27].

4.5. Analgesic Activity

As in its conventional application as an analgesic*, Plectranthus amboinicus* was revealed to have intense analgesic activity upon evaluation. Evaluation has revealed that plant extracts of different forms are beneficial in pain management, mechanisms potentially through interference with the modulation of pain pathways or through inhibition of inflammatory processes resulting in pain perception [23,27]. This is consistent with its conventional application in traditional medicine for headache, body ache, and other painful conditions.

4.6. Antitumor / Anticancer Activity

Newer studies point to potentially ample antineoplastic activity of *Plectranthus amboinicus.* As indicated in Table 2, in vitro studies have shown that methanol and ethyl acetate extracts of *P. amboinicus* were cytotoxic against several human cancer cell lines. Acosta et al.[1] documented an antineoplastic effect in macrophage tumour (Ehrlich carcinoma). Caroline et al. [7] were able to show anticancer effects on oral carcinoma cells. George et al. [13] characterized the cytotoxicity on A549 lung cells, and Hasibuan et al. [15] assessed both antioxidant and cytotoxic activity on breast and cervical cancer cells. Studies by Satria et al. [28] isolated β-sitosterol from *P. amboinicus* leaves and showed anticancer activity. Taken together, these results suggest that this species may be a source of chemotherapeutic agents [27].

4.7. Wound Healing Activity

The plant has been shown to stimulate tissue repair and regeneration much faster. Many studies have demonstrated the ability of aqueous extracts and from ointment bases to heal wounds in animal studies using both incision and excision wound models. Wound healing types of models include improved

wound contraction, collagen synthesis, and epithelization benefits compared to controls [20, 23, 27]. This supports its use in the common treatment of injuries and infections of the skin.

5. Other Pharmacological Activities

Aside from the important actions described above, additional scientific evidence has reported various other potential indicators of pharmacological activity in *P. amboinicus* that could sustain its wide-ranging traditional indications:

- **Diuretic Activity:** In line with its traditional uses for kidney and urinary tract conditions, investigational studies *with P. amboinicus* extracts demonstrated diuretic actions in animals with increased urinary output [18, 23, 27].

- **Anxiolytic Activity**: There was some indication that *P. amboinicus* could display some anxiolytic (anti-anxiety) activity, which could support its traditional use for calming [23].

- **Antiplatelet Aggregation Activity:** This activity provides potential cardiovascular benefits to inhibit the aggregates of platelets, which could decrease risk for clotting [23, 27]. that is also potentially demonstrated by proposed anti-hypertensive activity [27].

- **Antiepileptic Activity:** There is evidence, as noted by Bhattacharjee & Majumder [5] (Table 2), that alcoholic extracts of *Coleus amboinicus* (synonymous *P. amboinicus*) displayed anticonvulsant activity in vertebrate seizure models, which parallel its traditional indications for convulsions. An unpublished field report also coincides with the potential antiepileptic activity [6].

- **Antimalarial Activity:** This plant was mentioned to present antimalarial activity in certain traditional systems and preliminary studies [23, 27].

- **Anti-dandruff Activity*:*** *P. amboinicus*, known for anti-dandruff activity, is considered effective in trials [29].

- **Anti-obesity Activity:** There is some evidence to suggest possible effectiveness for reduction in obesity [27].

- **Immunomodulatory Activity:** The general activity of the plant for immunomodulation seems to contribute to full therapeutic action attributed to it [27].

- **Neuroprotective Activity:** The first studies may suggest that neuroprotective activity could, in fact, intervene with neurological health benefits [27].

- **Hepatoprotective Activity:** Some applications also provided “hepatopathy” that suggests protect activity in liver

- **Free Radical Scavenging and GC-MS Profiling:** More recent studies such as essential oil study from Odisha (Odisha essential oil study, 2023) still look into free radical scavenging activity and phytochemicals profile using GC-MS.

All these evidence from scientific validation certainly constrain towards the remedial span of *P. amboinicus* and strengthen the case for developing more modern medication from the plant.

6. Future Perspectives

Plectranthus amboinicus presents an interesting case of a traditional medicinal plant with great potential for future pharmaceutical uses. The extensive traditional uses documented in the anthropological and ethnomedicinal literature (as discussed and summarized in the previous sections and tables), combined with a developing totality of scientific support for its many pharmacological activities, makes it a strong candidate for drug discovery and development. Moving forward, there are several aspects of *Plectranthus amboinicus* that should be researched further to optimize its health benefits:

- **Mechanistic Studies:** There are numerous pharmacological activities which have been documented to date, however, there is still much to be learned regarding the mechanistic, molecular undertake and precise cellular targets that its bioactive molecules exert their pharmacologic actions on, e.g., receptor interactions, enzyme inhibition, type of signalling pathway action (e.g., inhibition-stimulation pathway) – needs more discussion.

- **Bioavailability and Safety Data:** There is no data available on the bioavailability, pharmacokinetics (absorption, distribution, metabolism, and excretion), and long-term safety data on its crude extracts and isolated compounds, no data is available to determine its effective dose in humans or to warn of significant adverse effects, possible drug interactions, or any other potential harmful consequences of prolonged use.

- **Clinical Trials:** There is enough evidence in support of the use of *Plectranthus amboinicus*, we need to conduct our due diligence in designing and carrying out controlled, reproducible clinical trials with rigorous attention to acceptable experimental design of disease conditions for which we possess authoritative preclinical support.

- **Standardization:** Producing standardized extracts with identical phytochemical constituents are critical to reproduce applications and for quality control purposes in pharmaceutical usage and is contingent on proper identification of a marker compounds which can be quantified.

- **Sustainable Cultivation and Conservation:** With increasing demand for *P. amboinicus*, it is therefore vital to not only research optimal and sustainable cultivation practices going forward that can meet demand for *P. amboinicus*, whilst also ensuring consistency of the active compounds present in an extract and avoid over-harvesting wild populations for the use of *P. amboinicus*.

- **Novel Drug Discovery:** Ongoing isolation and description of compounds with new or potentially unexplored bioactivity and conducting structure-activity related work on these

compounds would help stimulate new drug development, which are more efficacious and/or specific.

- **Combination Therapies:** t may be interesting to investigate extracts or isolates of *P. amboinicus* in combination with conventional pharmaceuticals to improve therapeutics aiming to produce less side effects.

7. Conclusion

In conclusion, *Plectranthus amboinicus* is much more than just a folk remedy; it is a phytochemical powerhouse with a complex chemical profile that supports a variety of health benefits. It's remarkable traditional use for a wide variety of ailments, combined with mounting empirical support for multiple biological (antibacterial, anti-inflammatory, antioxidant, antidiabetic, anticancer, wound healing) and pharmacological actions highlight its promise as a valid therapeutic development. Continued exploration and analysis of *Plectranthus amboinicus* using rigorous scientific methods, focusing on qualitative mechanisms, solid clinical efficacy, and standardization will continue to expand *Plectranthus amboinicus'* potential as a professional, research-backed ingredient in drug design, transitioning from a folk medicine product to another part of the future health care landscape

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