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Review Article

Exploring *Ipomoea cairica* as a Source of Bioactive Molecules: A Comprehensive Review of Its Phytochemistry and Biological Activities

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ABSTRACT:
Ipomoea cairica (L.) Sweet, commonly known as five-fingered morning glory or mile-a-minute vine, is a perennial climbing herb belonging to the family Convolvulaceae. The plant has long been utilized in traditional medicine across tropical and subtropical regions for the treatment of various ailments, including inflammation, infections, and liver disorders. This review provides a comprehensive overview of the taxonomy, morphology, phytochemical composition, and pharmacological properties of *I. cairica*. Phytochemical investigations have revealed the presence of diverse bioactive constituents such as coumarins, flavonoids, lignans, resin glycosides, and anthocyanins, which contribute to its wide range of biological activities. Experimental studies have validated its ethnomedicinal uses, demonstrating antioxidant, anti-inflammatory, antidiabetic, hepatoprotective, nephroprotective, neuroprotective, antimicrobial, larvicidal, and antifungal properties. These pharmacological effects are largely attributed to the plant's ability to modulate oxidative stress, inflammation, and enzymatic activity in various experimental models. Despite significant progress, further studies are required to isolate and characterize the specific active compounds responsible for these effects, elucidate their mechanisms of action, and assess their safety and therapeutic potential through preclinical and clinical evaluations. The cumulative evidence positions *I. cairica* as a promising natural resource for the development of novel pharmacotherapeutic agents.

Key Words- *Ipomoea cairica*; Convolvulaceae; Phytochemistry; Ethnomedicinal uses; Pharmacological activities; Antioxidant; Hepatoprotective

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INTRODUCTION

India's ancient medical system, Ayurveda, has been practised for over 1,000 years and remains deeply rooted in Indian society. With nearly 25,000 natural formulations used in folk medicine, particularly in rural areas, Ayurveda places a strong emphasis on the use of herbal remedies[1].

With more than 500 species, *Ipomoea* is the biggest genus of blooming plants and is found in tropical and subtropical climates. Growing from sea level to 2,600 meters, *Ipomoea cairica* is a pantropical species found throughout Africa, Australia, and Asia, including regions such as Buenos Aires and the Andes. It is mostly found in India and Sri Lanka, with significant populations in the Gulf of Mannar, Tamil Nadu, Maharashtra, and Andhra Pradesh [2].

Large, eye-catching white to lavender blooms and palmate leaves characterise this Climbing hydrangea. Its fruit has hairy seeds and reaches a maturity of approximately 1 cm. When fully grown, the stalks are hairy and hollow in shape, and the elliptic and lanceolate leaves have an acuminate apex and a cordate base, measuring 4–14 cm by 2.5–9 cm. The plant yields pubescent seeds, ovoid capsules, and many-flowered cymes with pale pink corollas that are 9 cm long.

Approximately 80% of people worldwide use traditional medicine to treat a variety of illnesses, according to the WHO [3]. Common bioactive ingredients in plant extracts include glycolipids, phenolic compounds, and alkaloids. Glycoresins are important chemotaxonomic indicators linked to the purgative qualities of some *Ipomoea* species, which are known to have medicinal potential. These species demonstrate numerous pharmacological actions, including antibacterial, analgesic, anti-inflammatory, anticoagulant, and anticancer effects. The diversity in morphology and habitat of Ipomoea plants makes them valuable for study. [4], [5], [6]

Ipomoea cairica (Convolvulaceae) is a perennial herb of unknown origin, possibly tropical Africa and Asia; widely cultivated, now distributed nearly pantropically. Grows in disturbed sites, such as roadsides and waste-ground in urban areas, and is invasive of natural habitats, especially along riverbanks and coastal dunes. A rampant, long-lived (i.e. perennial) climber reaching up to 5 m or more in height, or creeping along the ground [7], [8].

TAXONOMY

Kingdom: Plantae
Subkingdom: Viridiplantae
Super division: Embryophyta
Division: Tracheophyta
Class: Magnoliopsida
Order: Solanales
Family: Convolvulaceae
Genus: *Ipomoea*
Species: *cairica*

Common names

Five-fingered morning glory, mile-a-minute vine, Messina creeper, Cairo morning glory, coast morning glory and railroad creeper

MORPHOLOGY



Figure 1: *Ipomoea cairica* in natural habitat

Size

The alternately arranged leaves were divided into five or seven narrow lobes, like the fingers of a hand (*i.e*. they are palmately lobed). Length-3 to 10 cm; Width-3 to 10 cm; Colour: dark green- pale green; Odour: characteristic; Taste: Acrid to sour; Surface: plain surface green in colour, darker on the upper side and pale on the lower side of the leaf. Margin: Entire; Apex: sharp; Midrib: Upper surface midrib is prominent; Lower surface- midrib is prominent. These leaves are hairless (*i.e.* glabrous) and borne on stalks (*i.e.* petioles) 2-6 cm long [9] .

Stem

Stems up to 5 m, thinly angular, possibly tuberculate or smooth.

Leaf

Leaves ovate to orbicular in outline, palmately cut to the base into 5 lobes, these lanceolate or ovate-lanceolate to ovate or elliptic, 3-10 cm long, pseudostipules present.

Inflorescence

Inflorescences one or several flowered; peduncle 2-8 cm; bracts and bracteoles early deciduous, squamiform, small.

Flower

Sepals ovate, obtuse to acute, mucronulate, 4-6.5 mm long. Corolla purple or white with a pinkish or purplish base inside the tube, 5-6 cm long. Stamens included, unequal. Ovary glabrous; stigma 2-lobed.

Fruit

The fruit is capsule-shaped and subglobose, measuring 10 to 12 mm in length.

Seed

Seeds 2-4, ovoid, 4-6 mm long, hairy, short-tomentose or with long trichomes on the margins [2].

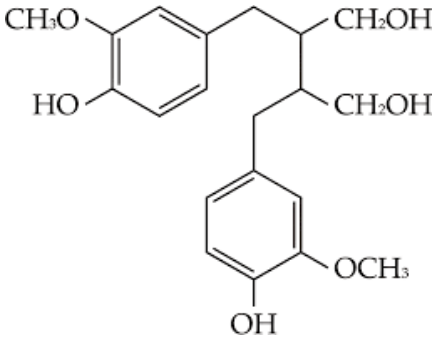
PHYTOCONSTITUENTS

The major constituents of the *Ipomoea cairica* are coumarins, scopoletin and umbelliferone and the lignans, arctigenin, matairesinol and trachelogenin [10]. In other research, the compounds obtained from *Ipomoea cairica* were (+) -(8R,8′S)-thujaplicatin methyl ether, arctigenin, matairesinol, trans-2,3-dibenzylbutyrolactone, vanillic acid, p-hydroxybenzoic acid, methoxybenzoic acid, methylparaben, stearic acid, palmitic acid, olenic acid, friedelinol and a mixture of β-sitosterol and stigmasterol [11]

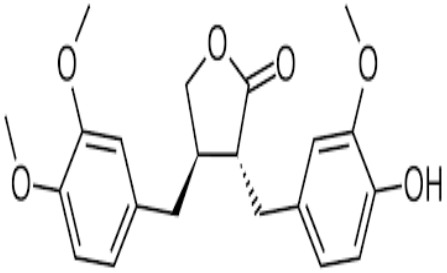
Four new acylated anthocyanins have been isolated from flowers of *Ipomoea cairica* (L.) Sweet. Pigments I and II were characterized as isomers of cyanidin-3-(p-coumaryl-caffeyl-sophoroside)-5-glucoside, IIIb as cyanidin-3-(dicaffeyl-sophoroside)-5-glucoside and IV as cyanidin-3-(caffeyl-sophoroside)-5-glucoside. Pigment IIIa was identified as cyanidin-3-(dicaffeyl-sophoroside)-5-glucoside, which has been described by Imbert *et al*. in Ipomoea batatas (L.) Lam. Anthocyanin IIIa is isomeric with IIIb. The presence of acylated pigments in the Tubiflorae order is of systematic interest [12].

Bangwei Yu *et al,* 2013 isolated six partially acylated pentasaccharide resin glycosides, cairicosides A–F, from the aerial parts of *Ipomoea cairica*. These compounds were characterised as a group of macrolactones of simonic acid A, partially acylated with different organic acids. These organic acids were identified as n-decanoic acid, 2-methylbutanoic acid, and trans-cinnamic acid [13].

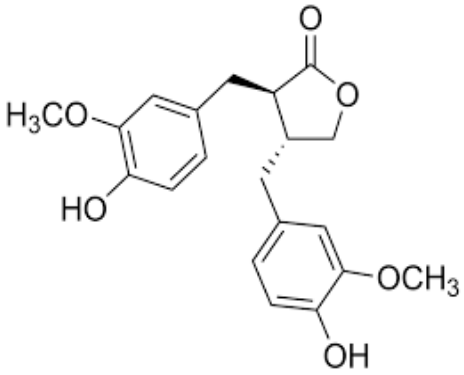
Ferreira A. A. *et al* performed microwave-assisted derivatisation and GC-MS analyses of amino acids from *Ipomoea cairica* aqueous extract, detected 18 out of the 20 protein amino acids simultaneously with excellent resolution for alanine, glycine, valine, leucine, serine, threonine, methionine, lysine, histidine, tyrosine, and tryptophan [14].



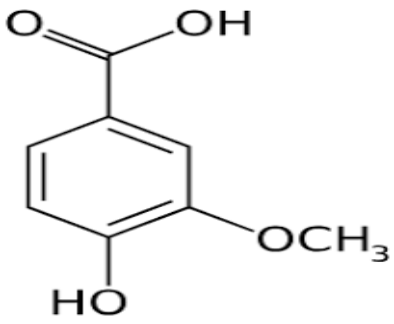
Lignan



Arctigenin



Matairesinol



Vanillic acid

PHARMACOLOGICAL ASPECTS

Anti-nociceptive activity

The ethanolic extract of *Ipomoea cairica* showed Anti-nociceptive activity. Ferreira *et.al.* carried out an experiment using male Swiss Mice (25–35 g) to check the activity of *Ipomoea cairic*a. Treatment with high doses of ethanolic extract or with the target doses of its fractions did not modify the carrageenan-induced

oedema, the latency of tail-flick reflex, or motor performance on the Rota-Rod. This was in contrast to the effects observed with the standard drugs, such as sodium diclofenac, morphine sulfate, and xylazine [15].

Antidiabetic activity

The in vitro α-glucosidase and α-amylase inhibition techniques were used to test the antidiabetic properties of Ipomoea cairica (L.) sweet leaf methanolic extracts, petroleum ether, ethyl acetate, and n-butanol fractions. For the first time, five flavonoids, including two uncommon flavonoid sulphates, were isolated from this plant by phytochemical analysis of the ethyl acetate fraction, which had the most antidiabetic effect. The compounds demonstrated α-glucosidase and α-amylase inhibitory action in vitro that was concentration-dependent. Additionally, the in-silico investigation suggested that drugs had strong interactions with protein tyrosine phosphatase 1b, α-glucosidase, and α-amylase [4].

Inhibitory activity

This study examined whether leaf extracts from *I. cairica* could inhibit *P. globosa* a common harmful algal bloom species on the southeast coast of China. The results showed that extract concentrations greater than 0.25 percent (v/v) reduced the proliferation of individual cells. Additionally, as the treatment duration increased, the activity of antioxidant enzymes such as catalase, peroxidase, and superoxide dismutase also increased. This indicates that cells utilise antioxidant enzyme defence mechanisms to mitigate the production of reactive oxygen species (ROS). Elevated levels of ROS can lead to cell death by rupturing cell membranes and altering cellular structures.[16]

Larvicidal activity

Since Ipomoea cairica has been demonstrated to have larvicidal effects on the genus Aedes, the current bioguided investigation examined the larvicidal capability of extracts fractionated using thin-layer and open-column chromatography. This study's goal was to assess the non-volatile components in an ethanolic extract of *I. cairica* stems as a possible natural larvicidal agent. Major compounds like umbelliferone and scopoletin were identified as coumarins, but their role in mediating the larvicidal action was not proven. According to the results of the larvicidal action tests, these coumarins may not directly cause the larvicidal activity; rather, the chemicals in the most active secondary fraction, known as F.DCM, may work in concert to produce this activity [17].

Another study revealed that the essential oil content in this plant is highly toxic to the larvae of *Culex tritaeniorhynchus*, followed by *Aedes aegypti*, *Anopheles stephensi*, and *Culex quinquefasciatus* mosquitoes. Larvicidal bioassays demonstrated that the plant's essential oil possesses potent activity, achieving 100% mortality against *Culex tritaeniorhynchus* at 100 ppm, *Aedes aegypti* and *Anopheles stephensi* at 120 ppm, and *Culex quinquefasciatus* at 170 ppm. The lethal concentration (LC_{50} and LC_{90}) values for *Cx. tritaeniorhynchus*, *Ae. aegypti*, *An. stephensi*, and *Cx. quinquefasciatus* were calculated as 14.8 and 78.3 ppm, 22.3 and 92.7 ppm, 14.9 and 109.9 ppm, and 58.9 and 161.6 ppm, respectively [18].

Neuroprotective activity

In male Wistar rats, the neuroprotective effect of *I. cairica* extract against cadmium-induced biochemical alterations in the brain was examined. A total of 36 animals were split up into four groups, each consisting of nine individuals. Acetylcholinesterase action, lipid peroxidation, beta-amyloid accumulation, caspase 3 and 9, p53, and glutamate levels were significantly increased after CdCl2 therapy. CdCl2 also significantly reduced the activities of glutathione-S-transferase, catalase, superoxide dismutase, Na+/K+ ATPase, and glutamate dehydrogenase. Through its antiapoptotic, anticholinesterase, antiexcitotoxicity, and antioxidant properties, ICE was able to lessen the neuronal damage caused by CdCl2 [19].

Antibacterial activity

The antibacterial activity of the aerial parts of *Ipomoea cairica* was evaluated using the agar well diffusion method. Bacterial strains employed in this study included *Pseudomonas aeruginosa* (ATCC), *Salmonella typhi* (ATCC), *Staphylococcus aureus* (ATCC), and *Escherichia coli* (ATCC). For the assay, 50 µL of the prepared extract (0.5 mg/mL in DMSO) and control solutions were carefully dispensed into the respective wells. The plates were left at room temperature for 60 minutes to allow diffusion, followed by incubation at 37 °C for 24 hours. Antibacterial efficacy was assessed by measuring the diameter of the inhibition zones (ZOI) surrounding each well. Furthermore, friedelin, a bioactive compound with established antibacterial activity, was isolated and characterised from the dichloromethane/methanol (DCM/MeOH) extract of *I. cairica*.[20].

The aerial parts of *Ipomoea cairica* have traditionally been used in African medicine for the treatment of microbial infections. Another study aimed to substantiate these ethnomedicinal claims by investigating the antimicrobial phytochemicals present in the plant. The aerial parts were extracted using a dichloromethane/methanol (1:1) solvent system, and the resulting extracts were fractionated chromatographically. Structural elucidation of the isolated compounds was performed using one- and two-dimensional NMR techniques, including ^1H NMR, ^13C NMR, COSY, HSQC, and HMBC. Antibacterial activity of both the crude extracts and isolated compounds was evaluated using the agar well diffusion method. Friedelin was isolated and identified for the first time from *I. cairica* through chromatographic analysis. Additionally, lupeol and a previously unreported compound, trans-fagaramide, were isolated from *Alstonia boonei*. Antibacterial testing revealed that trans-fagaramide exhibited a minimum inhibitory concentration (MIC) of 125 µg/mL against *Pseudomonas aeruginosa* and 250 µg/mL against *Staphylococcus aureus*, *Salmonella typhi*, and

Escherichia coli. Friedelin demonstrated an MIC of 125 µg/mL against *E. coli* and 250 µg/mL against the other tested pathogens.

These findings provide scientific support for the traditional use of *I. cairica* as a herbal remedy for bacterial infections. Further in vivo studies are recommended to evaluate the pharmacological efficacy, dosage safety, and potential toxicity of the extracts and isolated compounds to validate their therapeutic applicability [20], [21].

Hepatoprotective activity

Male Wistar rats were intraperitoneally administered cadmium chloride (3.5 mg/kg) following oral pretreatment with *Ipomoea cairica* leaf extract (ICE) at doses of 100 and 250 mg/kg. After 24 hours, the animals were sacrificed, and blood and tissue samples were collected for the evaluation of haematological parameters, oxidative stress markers, hepatotoxicity indicators, and antioxidant enzyme activities. Exposure to cadmium chloride ($CdCl_2$) resulted in a significant reduction in haemoglobin (Hb), packed cell volume (PCV), white blood cells (WBC), leucocytes, basophils, and eosinophils. In addition, levels of glutathione (GSH), catalase (CAT), superoxide dismutase (SOD), glutathione-S-transferase (GST), and malondialdehyde (MDA) were markedly reduced, indicating oxidative stress and hepatocellular damage. Pretreatment with ICE effectively mitigated these toxic effects, as evidenced by increased Hb and PCV, restoration of WBC and differential counts, elevated GSH levels, reduced MDA concentrations, and enhanced CAT, SOD, and GST activities.

These results demonstrate that *I. cairica* leaf extract confers significant protective effects against $CdCl_2$-induced haematological alterations and oxidative damage, suggesting its potential as a natural therapeutic agent for managing heavy metal toxicity [22].

Antifungal activity

Ipomoea cairica Sweet is a perennial climber herbaceous evergreen that grows up to 5 meters in length with thin stems and tuberous roots. The plant has shown significant antibacterial qualities, however its effectiveness varies. Aqueous, methanolic, ethanolic, and chloroform extracts from the plant's aerial parts were used to assess the extracts' in vitro antifungal efficacy against Streptomyces griseus, Rhizopus stolonifer, and Penicillium notatum using the agar well diffusion method. While antifungal activity was present in all extracts, the methanolic extract was the most effective, followed by the ethanolic extract. The least amount of activity was shown by the aqueous extract, especially against *R. stolonifer*. The findings showed that the presence of the extracts in the culture medium hindered the radial growth of all examined fungus, with the degree of inhibition rising in direct proportion to the extract content. A broad pattern of concentration-dependent growth suppression was noted, even though the response differed among fungal species [23].

In other work scientist confirmed *I. cairica* extract showed promising hepatoprotective activity against DCF-induced oxidative and inflammatory liver damage. In this study male Wistar rats were used to test the hepatoprotective efficacy of *I. cairica* leaf methanolic extract (MEIC) against liver damage caused by diclofenac (DCF). The 35 rats were split up into five groups: controls, DCF (100 mg/kg) rats, and rats that received MEIC pretreatment (100 or 250 mg/kg for 14 days). Lipid profiles, liver enzymes, pro-inflammatory enzymes (XO, MPO, NADP(H) oxidase), oxidative stress indicators (MDA, protein carbonyl), antioxidant markers (GSH, CAT, SOD), and liver enzymes were all examined in blood and liver samples. DCF decreased antioxidant activity and markedly raised oxidative stress and hepatic enzyme levels ($P<0.05$). These effects were lessened by pretreatment with MEIC, suggesting its protective function [24].

Antioxidant activity

Researchers compare the antioxidant activity of several solvent extracts of *I. cairica* that were made using Soxhlet extraction. Petroleum ether, methanolic, and ethyl acetate extracts were made; the phytochemical makeup and antioxidant potential of the methanolic and ethyl acetate extracts were then assessed. Standard assays were used, such as the superoxide (SOS) and hydrogen peroxide ($H2O_2$) radical scavenging tests. The methanolic extract outperformed the ethyl acetate extract in terms of antioxidant activity across all assays and overall phenolic and flavonoid levels, according to the results. With implications for maximizing its usage in pharmaceutical applications, these findings underscore the significance of solvent selection on extraction efficiency and highlight *I. cairica* as a viable natural source of antioxidants. DPPH radical scavenging assay was used to assess the antioxidant properties of methanolic extracts of *I. cairica* flowers and foliage. A quantitative assessment of scavenging activity is made possible by the color decrease that occurs when the DPPH radical, a persistent free radical with an absorption maximum at 517 nm, interacts with antioxidant chemicals. The extracts showed antioxidant properties that were depending on concentration. With an IC_{50} value of 1.00 µg/mL and 93.24% inhibition at 0.05 mg/mL, *I. cairica* floral extract demonstrated the strongest radical scavenging activity and the leaf extract of *I. cairica* had the lowest activity (IC_{50} = 4.00 µg/mL). The greater concentration of phenolic and flavonoid components in *I. cairica* flowers may be the cause of their better antioxidant ability [21], [25], [26].

Nephroprotective activity

Excessive use of NSAIDs, such as diclofenac (DFC), exacerbates acute kidney injury (AKI), a worldwide noncommunicable disease that results in liver, kidney, and ulcer damage. In this work, the nephroprotective ability of *I. cairica* leaf extract (ICE) against renal toxicity caused by diclofenac (DCF) in rats was examined. Five groups (n=7) of 35 rats were created: control, DCF-only (100 mg/kg), and two groups that received ICE pretreatment (100 and 250 mg/kg) for 14 days before being exposed to DCF. Blood and kidney tissues were subjected to biochemical assays to evaluate

pro-oxidant/inflammatory enzymes (NADPH oxidase, xanthine oxidase, myeloperoxidase), antioxidant enzymes (superoxide dismutase, catalase, glutathione peroxidase, glutathione-S-transferase), oxidative stress parameters (malondialdehyde, protein carbonyl), and renal function markers (creatinine, urea, and electrolytes).The findings showed that DCF decreased electrolyte concentrations (Na^+, K^+, Cl^-) and considerably increased serum creatinine levels (53.92%, $p<0.001$). Additionally, DCF suppressed the activities of antioxidant enzymes while raising oxidative stress and inflammatory indicators. These alterations were successfully restored by pretreatment with ICE, which showed notable renoprotective, antioxidant, and anti-inflammatory properties [27].

CONCLUSION

Ipomoea cairica has been traditionally recognized for its wide range of ethnomedicinal applications and remains an important source of bioactive compounds. Experimental studies have validated many of these traditional claims by demonstrating diverse pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, neuroprotective, nephroprotective, and larvicidal effects. The presence of coumarins, flavonoids, lignans, and resin glycosides appears to contribute significantly to these pharmacological actions. However, further research is necessary to isolate and characterize the specific bioactive molecules responsible for these effects and to evaluate their mechanisms of action, pharmacokinetics, and safety in clinical settings. Sustainable cultivation, proper standardization, and comprehensive pharmacological investigations of *I. cairica* will help to establish its therapeutic potential as a promising natural remedy in modern medicine.

Conflict of Interest

The authors affirm that no financial or business ties existed at the time the study was carried out that could be interpreted as perhaps having a conflict of interest.

Authors Contribution:

Formal analysis, investigation, data curation, writing (original draft), writing (review & editing), and final approval by all the authors.

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