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A COMPREHENSIVE REVIEW OF *MIRABILIS JALAPA* L.: PHYTOCHEMISTRY, PHARMACOLOGICAL ACTIVITIES, AND THERAPEUTIC POTENTIAL

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ABSTRACT: *Mirabilis jalapa* L., commonly known as the Four O' Clock plant, is a perennial herb belonging to the family Nyctaginaceae. Besides its ornamental importance, the plant has been extensively utilized in traditional medicine for the treatment of inflammation, infections, wounds, diabetes, and various other ailments. The present review summarizes the botanical characteristics, taxonomy, geographical distribution, traditional uses, phytochemical constituents, and pharmacological activities of *M. jalapa*. Phytochemical investigations have revealed the presence of diverse bioactive compounds, including flavonoids, alkaloids, triterpenes, sterols, glycosides, proteins, peptides, and betalain pigments distributed throughout different plant parts. Experimental studies have demonstrated a wide range of biological activities such as antibacterial, antioxidant, anti-inflammatory, antidiabetic, antiviral, antiasthmatic, antinociceptive, wound-healing, antispasmodic, anticancer, antifungal, anthelmintic, and hepatoprotective effects. These pharmacological properties support many of its traditional medicinal applications. The accumulated evidence suggests that *M. jalapa* represents a valuable source of natural therapeutic agents and warrants further investigations to isolate active constituents, elucidate mechanisms of action, and validate its efficacy and safety through clinical studies.

INTRODUCTION: For millennia, people have utilised plants as a kind of traditional medicine. India contributes 15–20% of the 20,000 medicinal plants classified by the WHO worldwide. Eighty percent of the world's nations rely on medicinal herbs, according to the WHO ^{1, 2}. Research on medicinal plants has drawn a lot of attention because it highlights the many unidentified therapeutic benefits, particularly those derived from plants, which require assessment using contemporary scientific methods like chemical analysis, pharmacological research, pharmacokinetic and pharmacodynamic studies, and clinical trials ^{3, 4}.

The perennial decorative and therapeutic herb *Mirabilis jalapa* is a member of the Nyctaginaceae family ⁵. The plant's blossoms often open in the late afternoon, earning it the nickname "Four o'clock plant." It is extensively grown for its fragrant and vividly coloured blooms ⁶. In addition to its aesthetic appeal, the plant has long been utilised in many medical systems to treat wounds, diabetes, inflammation, infections, and digestive issues. Important bioactive substances with a variety of pharmacological characteristics may be found in the plant's roots, leaves, flowers, and seeds, among other sections ^{7, 8, 9}.

Taxonomy: *Mirabilis jalapa* belongs to the kingdom Plantae and is classified under the division Magnoliophyta. It is placed in the class Magnoliopsida and belongs to the order Caryophyllales. The plant is a member of the family Nyctaginaceae.

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Its genus is *Mirabilis*, and the scientific name of the species is *Mirabilis jalapa* L.⁹

Common Names: *Mirabilis jalapa* is known by different common names in various languages and regions. In English, it is commonly called Four o'clock plant or Marvel of Peru. In Hindi, it is known as Gulabbas, while in Sanskrit it is referred to as Krishnakeli. The plant is called Andhi Mandarai in Tamil, Chandrakanta in Telugu, Naalu Mani Poo in Malayalam, and Sanje Mallige in Kannada¹⁰.

Habitat and Geographical Distribution: Originally from tropical America, particularly Peru, *Mirabilis jalapa* is now found in many tropical and subtropical parts of the world¹¹. Gardens, roadsides, wastelands, grasslands, and farmed fields are typical habitats for the plant. It grows best on rich, well-drained soils in full sun and thrives in warm climates with moderate rainfall. Because of its decorative and therapeutic value, the plant is widely grown in India, China, Africa, Southeast Asia, Europe, and the Americas¹². It readily adjusts to various climatic conditions and can withstand drought conditions.



FIG. 1: MIRABILIS JALAPA PLANT

Traditional Uses: *Mirabilis jalapa* is widely used in traditional medicine across many regions for the treatment of various ailments.

Antiviral Activity: It has long been known that the plant possesses antiviral qualities.

Anticancer Potential: In conventional medicine, it is also acknowledged for its possible anticancer action¹³.

Anti-Inflammatory Effect: The leaves are frequently used to treat inflammatory diseases and lessen inflammation.

Botanical Description:

Habit: Bushy, perennial herb growing up to about 1 meter in height.

Stem: Thick, branched, swollen at the nodes, and green to reddish in color.

Leaves: The leaves are simple, ovate to heart-shaped, and arranged alternately on the stems. They have a smooth texture and can vary in size.

Flowers: Funnel-shaped and fragrant. Found in various colors such as pink, yellow, red, white, and purple. Different colored flowers may occur on the same plant. Flowers usually bloom in the late afternoon or evening, giving rise to the common name "Four O' Clock Plant."

Fruits/Seeds: Produce small, spherical, black seeds enclosed within a hard seed coat.

Roots: The roots are tuberous and fleshy, and they have traditionally been utilised for medicinal purposes. They are often picked for their purgative effects^{13, 14, 15}.

Purgative and Diuretic Qualities: The plant's various components are used as a purgative (to treat constipation) and diuretic (to encourage urine flow).

Wound Healing (Vulnerary): The plant's leaf juice is historically administered as a vulnerary to aid in the healing of wounds.

Uses of the Roots: Traditionally used to cure dropsy (oedema), the roots are said to have aphrodisiac, diuretic, and purgative qualities.

Abscess Treatment: Traditionally, abscesses are treated using a decoction made by crushing and boiling the leaves^{14–18}.

vital minerals, are found in various regions of *Mirabilis jalapa*.

Phytochemistry: Numerous phytoconstituents, including as alkaloids, flavonoids, phenolic compounds, tannins, glycosides, saponins, terpenoids, steroids, carbohydrates, proteins, and

The plant's many pharmacological and medicinal qualities are caused by these bioactive substances.

TABLE 1: PHYTOCONSTITUENTS PRESENT IN DIFFERENT PARTS OF PLANT MIRABILIS JALAPA

Plant part	Phytochemical constituents	Reference
Aerial Parts	Triterpenes, Flavonoids	[19]
Roots	Resin (3%), Trigonelline, Oxymethylantraquinone, Carbohydrates (yielding galactose and arabinose)	[20–22]
	Astragaloside-II, Astragaloside-IV, Astragaloside-VI, Flazin	[23]
	4'-Hydroxy-2,3-dihydroflavone-7-β-D-glucopyranoside, Gingerglycolipid-A, 3,4-Dihydroxybenzaldehyde, p-Hydroxybenzaldehyde, β-Sitosterol	[24]
	Daucosterol	[25]
	Virucidal proteins	[26]
	Stigmasterol, β-Sitosterol	[27]
	Linear D-Glucan (1→3 and 1→4 linkages)	[28]
	Ribosome-inactivating protein (RIP)	[29]
	Mirabijalone A, B, C, D	[30]
	9-O-Methyl-4-hydroxyboeravinone-B, Boeravinone-C, Boeravinone-F	[31, 32]
	1,2,3,4-Tetrahydro-1-methylisoquinoline-7,8-di-diol	[33]
	Boeravinone, (2,5-di-oxo-imidazoline-4-yl)-urea, Glycerinmonoeicosate, β-Sitosterol	[34]
Leaves	Quercetin	[35]
	C-Glycosyl flavonoid	[36]
	Tricosan-12-one, n-Hexacosanal, β-Sitosterol, Tetracosanoic acid	[37]
	Tartaric acid, Citric acid, Leucine, Valine, Tryptophan, Alanine, Glycine	[37]
	D-Pinitol (O-methyl inositol)	[38, 39]
	N-trans-Feruloyl-4'-O-methyldopamine	[40]
Stems	Alkaloids, Carbohydrates, Tannins, Unsaturated hydrocarbons, Flavonoids	[41]
Seeds	8-Hydroxy-octadeca-cis-11,14-dienoic acid	[42]
	Arginine, Glycine, Histidine, Threonine, Tyrosine, Aspartic acid, Glutamic acid	[43]
	D-Glucan (38 glycosyl units)	[43]
	β-Sitosterol, β-Amyrin	[44]
	β-Sitosterol-D-glucoside, β-Amyrin-3-O-α-L-rhamnosyl-O-β-D-glucoside	[45]
	Antimicrobial peptides (Mj-AMP-1 and Mj-AMP-2)	[46]
Flowers	Miraxanthins I–III, Miraxanthin IV	[47]
	Indicaxanthin, Vulgoxanthin I	[48]
	Betaxanthins	[49]
Callus	Plant virus inhibitor	[50]
	Increased MAP production under KH ₂ PO ₄ supplementation	[51]
	Isoflavone, Dehydrorotenoid, Rotenoid	[52]

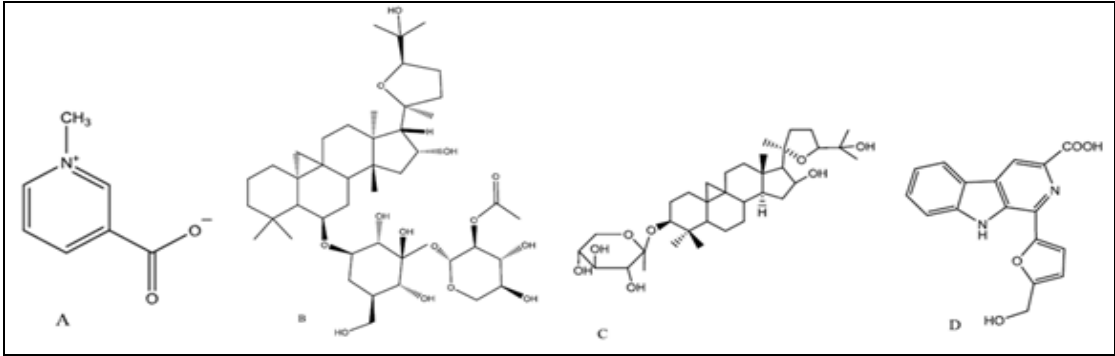


FIG. 2: STRUCTURES OF COMPOUNDS FROM A-D. A) TRIGONELLINE; B) ASTRAGALOSIDE-II; C) ASTRAGALOSIDE-IV; D) FLAZIN

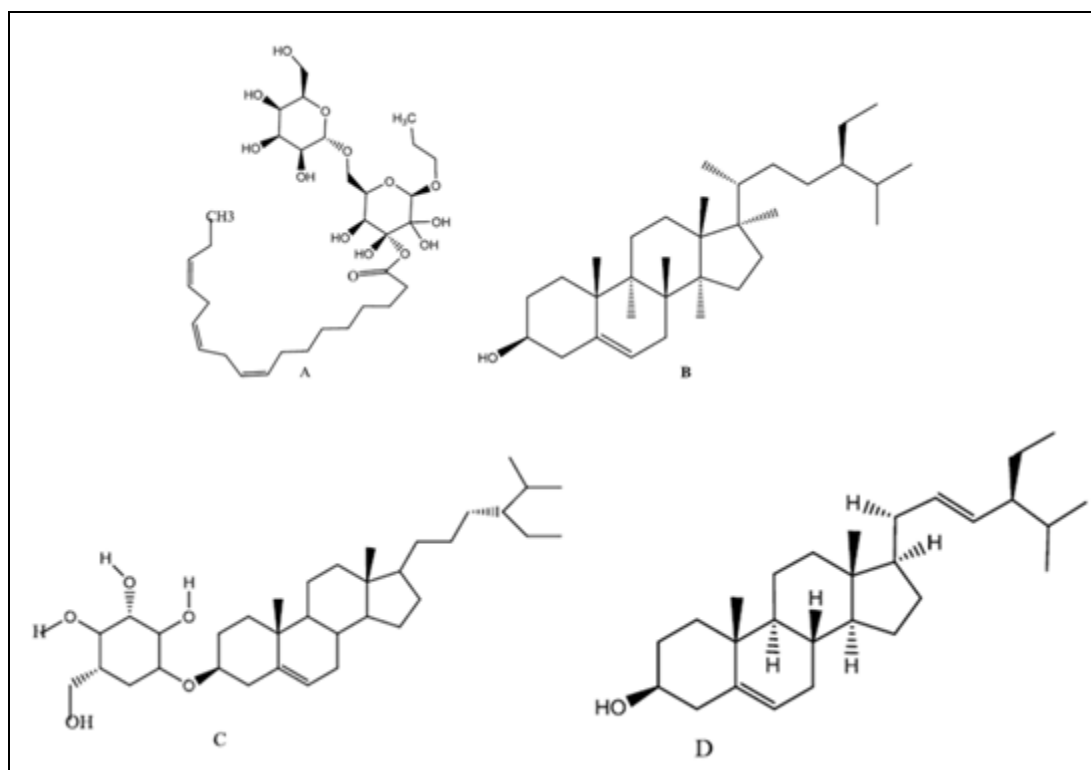


FIG. 3: STRUCTURES OF COMPOUNDS FROM A-D. A) GINGERGLYCOLIPID-A; B) 3,4-DIHYDROXYBENZALDEHYDE; C) DAUCOSTEROL; D) STIGMASTEROL

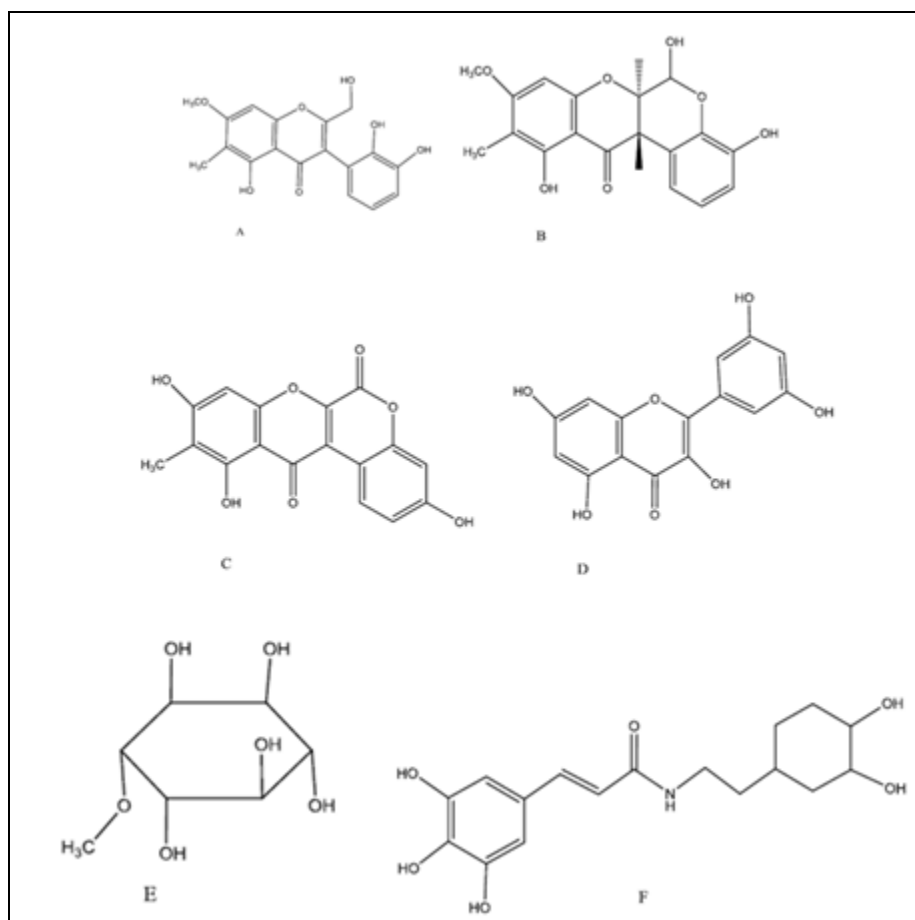


FIG. 4: STRUCTURES OF COMPOUNDS A-F. A) ROTENONDS MIRABIJALONE A, B, C; B) BOERVINONE-C; C) 1,2,3,4-TETRAHYDRO-1-METHYLISOQUINOLINE-7,8-DI-DIOL; D) FLAVONOIDS QUERCETIN; E) O-METHYL INOSITOL; F) POLYPHENOLIC AMIDE N-TRANS-FERULOYL-4'-O-METHYLDOPAMINE

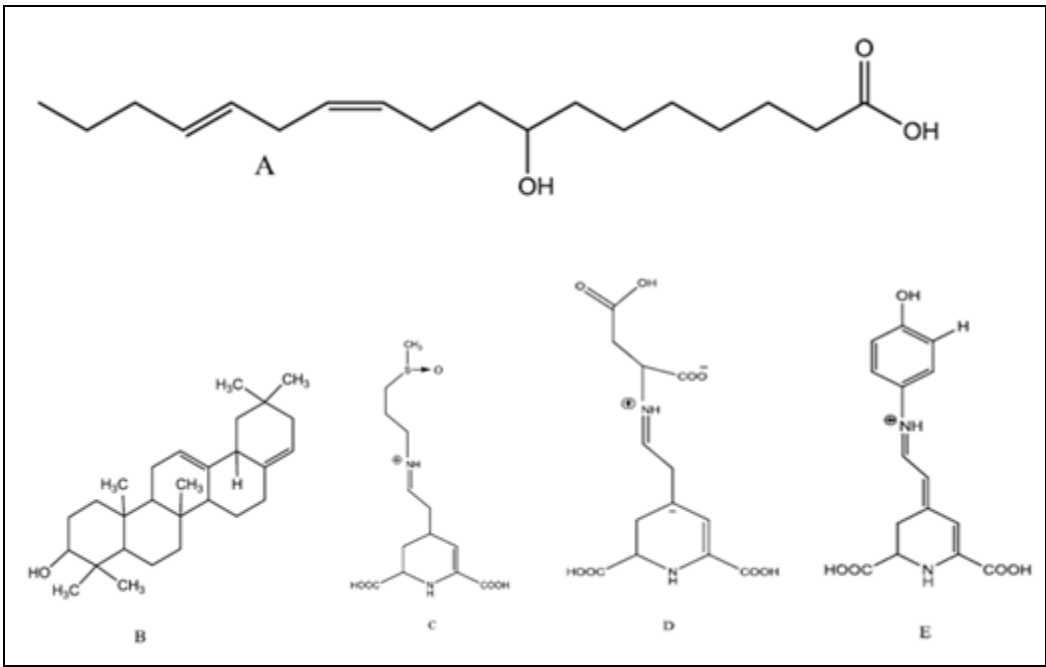


FIG. 5: STRUCTURES OF COMPOUNDS A-E. A) 8-HYDROXY-OCTADECA-CIS-11,14-DIENOIC ACID; B) B-SITOSTEROL, B-AMYRIN; C-E) MIRAXANTHINS I-III

Pharmacological Activity: *Mirabilis jalapa* is widely used in both traditional and modern medicine due to its wide range of pharmacological activities, which include anti-inflammatory, antioxidant, antimicrobial, antiviral, antitumor, analgesic, hepatoprotective, and antidiabetic activity.

TABLE 2: PHARMACOLOGICAL ACTIVITIES OF

Pharmacological Activity	Plant Part / Extract Used	Key Findings	Ref.
Antibacterial Activity	Ethanollic leaf extract	Effective against both Gram-positive and Gram-negative bacteria; activity confirmed by cup plate and disc diffusion methods using streptomycin as standard.	[53]
Antioxidant Activity	Acetone, ethyl acetate, petroleum ether, and ethanollic leaf extracts; methanol bark extract	Ethanollic leaf extract showed highest antioxidant potential in FRAP assay. Methanol bark extract showed DPPH radical scavenging activity (IC ₅₀ = 598.02 µg/ml).	[54,55]
Anti-inflammatory Activity	Total alcoholic extract and petroleum ether fraction of leaves; aqueous leaf extract	Significant inhibition of inflammation in carrageenan-induced paw edema and cotton pellet granuloma models; reduced fibroblast proliferation and collagen synthesis.	[56,57]
Antidiabetic Activity	Ethanollic root extract	Reduced serum glucose, triglycerides, urea, creatinine, total cholesterol, LDL, and glucose-6-phosphatase activity; increased insulin, HDL, protein, liver and muscle glycogen levels. Useful in Type II diabetes management.	[58]
Antiviral Activity	Leaf extract, root proteins, suspension cultures	Active against HSV-I, VSV, and Tobacco Mosaic Virus (TMV); contains ribosome-inactivating proteins (RIPs) and MAP (Mirabilis Antiviral Protein).	[58,59]
Antiasthmatic Activity	Ethanol and acetone root extracts	Demonstrated antiasthmatic activity in guinea pig tracheal chain preparation and clonidine-induced mast cell degranulation models.	[60]
Antinociceptive Activity	Whole plant extracts	Exhibited analgesic and pain-relieving activity in mice, supporting traditional use in painful conditions.	[61]
Dermatological (Wound Healing) Activity	Ethanollic leaf extract (1000 mg/kg bw)	Enhanced wound contraction, wound-breaking strength, dry tissue weight, and hydroxyproline content in diabetic wound models.	[62]
Antispasmodic Activity	Flower extract	Inhibited gut smooth muscle contraction (IC ₅₀ = 18 ± 0.7 µg/ml) and stimulated rabbit aortic muscle contraction	[63]

Anticancer Activity	<i>Mirabilis jalapa</i> proteins	(EC ₅₀ = 11.60 ± 0.26 µg/ml). Cytotoxic against T47D, SiHa, MCF-7, A549, and HCT-116 cancer cell lines; exhibited strong apoptotic activity with lower toxicity toward normal cells.	[64]
Antifungal Activity	Methanol extract; isolated phenolic compounds	Active against <i>Aspergillus niger</i> , <i>Fusarium solani</i> , <i>Fusarium oxysporum</i> , <i>Fusarium granulation</i> , and <i>Candida albicans</i> ; inhibited growth of <i>Daedalea flava</i> .	[65]
Anthelmintic Activity	Methanolic extract of aerial parts and roots	Showed dose-dependent anthelmintic activity effective against parasitic worm infections.	[66]
Antitubercular / Hepatoprotective Activity	Leaf extract	Protected against hepatotoxicity induced by antitubercular drugs.	[67]

CONCLUSION: *Mirabilis jalapa* L. is an important medicinal and ornamental plant with a long history of traditional use. Scientific studies have confirmed the presence of numerous phytoconstituents, including flavonoids, alkaloids, sterols, glycosides, proteins, and beta linal pigments, which contribute to its diverse pharmacological activities. Various extracts and isolated compounds have demonstrated antibacterial, antioxidant, anti-inflammatory, antidiabetic, antiviral, anticancer, antifungal, wound-healing, and other therapeutic properties.

These findings validate many of its ethnomedicinal applications and highlight its potential as a source of novel bioactive molecules. However, further research focusing on standardization, toxicity evaluation, pharmacokinetics, molecular mechanisms, and well-designed clinical trials is required to establish its therapeutic efficacy and safety. Overall, *M. jalapa* holds significant promise for the development of plant-based pharmaceutical and nutraceutical products.

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