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Review

Mirabilis jalapa: A review of ethno and pharmacological activities

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ABSTRACT

Plants have been used for thousands of years to treat, prevent, and control a variety of diseases throughout the world. The initial benefits of using plant-derived medicine are that they are relatively safer than artificial alternatives. *Mirabilis jalapa* Linn. (Nyctaginaceae) is one of the plants that used for health care and medicinal purposes for several thousands of years. It is a perennial bushy herb promulgate by flowers or leaves, a native of America and commonly known as 'four-o-clock'. It has traditionally been used in the treatment of gastrointestinal disorders, muscle pain, abdominal colic, and diarrhea in ancient Mexico, Japan, China and Brazil. The literature review revealed that *M. jalapa* is widely used as anti-oxidant, anti-inflammatory, anti-microbial, anti-diabetic, cytotoxic, antinociceptive, and several other's medicines. In aerial parts of the *M. jalapa*, triterpene and flavonoids are found. Flowers mostly contain anthocyanins and flavonoids. Carbohydrate, resin and alkaloids are found in roots. Tricosan-12-one, n-hexacosanal, β-sitosterol, and tetracosanoic were isolated from the leaves of the *M. jalapa*. Seeds contain β-sitosterol, β-amyrin and β-sitosterol-D-glucoside. The presence of various bioactive compounds validates the whole plant for different medicinal practitioners. It has been extensively used in almost all folklore remedies worldwide for treating a variety of conditions. It has also been used for reducing agents for the production of gold nanoparticles. The purpose of my review is to find out the areas of scope and to give the detail of the work done on *M. jalapa* Linn. The present review article focused on ethno-pharmacological and other essential aspects of *M. jalapa* Linn in an attempt to provide a direction to further research.

Keywords*: Mirabilis jalapa* Linn, ethno-pharmacological, biological activity, chemical constituents.

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INTRODUCTION

Medicinal plants were very commonly available in abundance in the tropics. During recent years, many of these natural sources have been destroyed by over exploitation and deforestation. Apart from the use in the treatment of illness through self-medication, these medicinal plants are valuable for modern medicine in other ways. The relatively lower incidence of adverse reactions to plant preparations compared to modern pharmaceuticals is encouraging both the consuming public and national health care institutions to consider plant medicines as alternatives to synthetic drugs. From ancient times people use the medicinal plant for healing and treatment of disease. Traditional use of the medicinal plant is the fundamental source of medicine. Our peoples use a lot of plants for their treatment and healing. From the perspective and for the increasing price of the modern drug it will be the alternative. Today plant-based drugs continue to play an essential role in health care. It has been estimated by the World Health Organization that 80 percent of the population of the world rely mainly on traditional medicines for their primary health care (Subin et al., 2011; Farnsworth et al., 1985). A great part of the modern pharmaceutical industry has developed on the basis of medicinal plants by indigenous people and local communities. Traditional herbal medicine and plants have been used for health and medicinal purposes for

several thousands of years. The number of higher plant species is about 25000 on earth. It is estimated that 35000 to 70000 species have, at one time or another, been used in some cultures for medicinal purposes. One of these is genus *Mirabilis* which is traditionally used for medicinal purposes. *Mirabilis* is a genus of the Nyctaginaceae family (Table 1), mainly native of America, and commonly known as the four-o-clock flower. *Mirabilis* comprises approximately 50 species distributed primarily in tropical and temperate regions of the world. *Mirabilis Himalaya* is indigenous to the Himalayas, the only species native outside of the western hemisphere. Some species are ornamental and are cultivated in the world's warmer parts. Several of the American species are common and widespread. Historically, generic and species determination of *Mirabilis* are varied. *Mirabilis* was formally proposed by Linnaeus in 1753. Choisy provided the first synopsis of the genus in 1849 (Irena et al., 2007). He recognized the genus *Mirabilis* only in warmer parts of America. Genus *Mirabilis* have many unique biological features and medicinal importance. Several are extensively used as a medicinal plant in almost all folklore remedies worldwide for treating various diseases. However, studies have evidenced its antimicrobial, antiviral, and antioxidant activities. Chemical analysis of multiple species revealed alkaloids, flavonoids, phenols, steroids, triterpenes, glycosides, tannins, saponins, lignins, and several other constituents. The flower of the *Mirabilis jalapa* exhales a strong odor a night, which stupefies and capable of driving away from the mosquitoes (Kirtikar and Basu, 1935). The medicinal properties of *M. jalapa* have been well characterized in several studies. A protein purified from the root tubers of *M. jalapa* was confirmed to be an antiviral protein. This has been shown to inhibit the mechanical transmission of tomato mosaic virus (TMV) in tobacco, tomato, and pepper plants, and cucumber green mottle mosaic virus in cucumber plants. While the protein also has an inhibitory effect on cell-free protein synthesis and an anti-proliferative effect on tumor cells, it inhibits in vitro protein synthesis of prokaryotes and eukaryotes. It is extensively used for the treatment of dysentery, diarrhea, conjunctivitis, edema, inflammation, swellings, muscular pain, swelling, and abdominal colic, also used as a laxative by people from different countries. The extract of *M. jalapa* has also been reported to possess various bioactivities, including antibacterial, antiviral, antifungal, protein synthesis inhibition, antimicrobial, antinociceptive, and anti-gonorrhoeal antispasmodic, diuretic, carminative, cathartic, hydragogues, purgative, stomachic, tonic, and vermifuge properties. Several constituents have been isolated from the root and aerial parts of this plant, including some rotenoids, an isoquinoline derivate, terpenoids, steroids, phenolic compounds, d-glucoside, ursolic acid, mirabalisoic acid, trigonelline, an antiviral protein, alanine, alphaamyrins, arabinose, beta amyrin, campesterol, daucosterol and dopamine (Chetty et al., 2008).

Table 1. Taxonomic classification.

Kingdom	Plantae
Sub kingdom	Trcheobionta
Division	Angiosperms
Class	Dicotyledons
Sub-class	Caryophylidae
Order	Caryophylidae
Family	Nyctaginaceae
Genus	*Mirabilis*
Species	Jalapa

MORPHOLOGY

Mirabilis jalapa Linn. usually grows 0.6 to 0.9 m tall and just as wide (Figure 1). Leaves are pointed; flowers usually open from late afternoon onwards, hence the first of its common names. Flowers in groups of three, flowers with five green bracelets; surround the perianth; usually yellow; crimson, white or variegated and opening in the evening. Perianth lobes are five, gamophyllous, stamens five with unequal filaments. Carpel one, unilocular, superior ovary with a single ovule, a nectariferous disc surrounds the ovary. Fruit achene surrounded by a leathery, ribbed, persistent perianth. The self-compatible, the perfect flowers, each has 5 to 6 stamens and a single- ovule ovary. Fruits are coriaceous obovoid and roots are prominent tuberous. The single-seeded fruits are spherical, wrinkled, and black upon maturity, having started out greenish-yellow (Table 2) (Khurian, 2003).

Pollen morphology

The shape of the pollen grains of *M. jalapa* is spheroidal, oblate spheroidal, with a diameter ranging from 125 to 140 µm and thickness of 10 to 15 µm. Exine ornamentation is Spinulose; spinules 0.5 to 1 µm high, randomly distributed, aperture type pantoporare with numbers ranging from 18 to 20 the diameter of aperture varies between 6.3 and 10 mm while the membrane of the aperture is Margin ornate, membrane provided with spinulose and granules (Table 2). Pollen dimorphism is frequently found in this species (white-pink, mixed and mixed radiated); occasional giant, dimorphic anomalous, deformed, and joint grains have been observed. All these anomalous pollen grains except giant pollen grains are sterile (Pramanick et al., 2015).

Vernacular name

Andhra Pradesh: Chandrakantha; **Assamese**: Godhuli gopal; **Bengali**: Sandhyamaloti; **Brazil**: Marvel; **China**: Xizao hua; **France**: Belle de nuit; **Hebrew**: Lilanit Rav-Gonit; **Indonesia**: Bunga pukul empat; **Japan**: Oshiroi-

Figure 1. Morphology of different parts of *Mirabilis jalapa.*

Table 2. The morphological features of *Mirabilis jalapa* Linn.

Plants part	Morphological features
Seeds	Olive, brown or black in color.
Flowers	Tubular, cluster, funnel-shaped, single or double, fragrant, color usually purple and white, yellow or pink, arranged in group three flowers with five green bracteols, surrounding the perianth, usually yellow crimson, white or variegated and opening in the evening.
Roots	Perennial tuberous roots, fairly thickened, stem swollen at nodes.
Leaves	Opposite, 3.5-7.5 cm wide, 5-10 cm long, unequal, ovate to sub cordate.

bana; **Karnataka**: Sanje mallige; **Kerala**: Naalumani ; poovu; **Maithili**: Sanjhaa phool ; **Netherlands**: Nachtschone; **Pakistan**: Gul adnan, gul-e-abbas; **Persian**: Laleh abbasi; **Sri Lanka**: Hendirikka; **Turkish**: Akşam sefası.

HABITAT

This weedy species can be found all over the world distributed sites include, waste ground, old home sites. It also cultivated anthropogenic, meadows and fields. It is

the most commonly grown ornamental species of *Mirabilis* and is available in a range of colors. *M. jalapa* is a herbaceous plant with numerous branches, perennial plants that exist in southern and warm western regions, and an annual in the cooler northern region of its native tropical South America. It has been naturalized in many parts of the world (The Merck Index, 2001).

PHYTOCHEMISTRY

Roots

The root is the largest source of biological content in *Mirabilis jalapa* Linn. The roots contain 3% resin, trigonelline (Figure 1) (The wealth of India: raw materials, 1998) carbohydrate which on hydrolysis yields galactose and arabinose (Figure 2). By using column chromatography and NMR and mass spectrography as astragaloside-II flazin (Figure 2) some of the phytoconstituents are isolated from root. An anti-plant viral protein active against mechanical transmission of plant viruses was isolated and purified from roots using ammonium sulfate precipitation and ion-exchange chromatography. Rotenoid mirabijalone A, B, C, and D (Figure 2) (Saha et al., 2020) along with 9-O-methyl-4-hydroxyboeavinone-B (Figure 2) and 1,2,3,4- tetrahydro-methylisoquinoline-7,8-diol were isolated from the root. Boeavinone, urea, glycerin monoeicosate, and beta-sitosterol (Figure 2) were isolated from 75% ethanol roots extract. The study suggests consumption of *Mirabilis jalapa* root may prevent the complication of hyperglycemia associated with diabetes (Wang and Dai, 2012).

Leaves

Leaves are another rich source of biologically important constituents. In the ancient Indian subcontinent, *Mirabilis jalapa* leaves were used as traditional medicine as well as in the modern era. Flavonoids quercetin and C-glycosyl-flavonoid are reported in leaves. Tricosan-12-one, n-hexacosanal, β-sitosterol (Figure 2), and tetracosanoic acid were isolated from the leaves, and tartaric acid, citric acid, leucine, valine, tryptophan, alanine, and glycine were detected using paper chromatography (Zhou et al., 2012).

Seeds

There have been a lot of chemical contents found in *M. jalapa* Linn. seed that are used in the treatment of various diseases. Fatty acid was found in seed oil as a minor component and designated as 8- hydroxyl-octadeca-cs-11, octadeca-14-dienoic acid (Figure 2). Amino acid such as arginine, histidine, glycine, threonine, tyrosine (Figure 2) was found in seeds (Michalet et al., 2007). Two novel antimicrobial peptides named Mj-AMP-1 and Mj-AMP-2 were also isolated and purified from seeds and characterized (Cammue et al., 1992).

Flowers

In contrast to other parts, the flower has not many biologically potent constituents. But some of the biological contents were isolated from *M. jalapa* flowers such as miraxanthins I-III, Miraxanthins IV (Figure 3), indicaxanthin (Figure 3), and vulgoxanthin (Figure 3). Betaxanthins (Figure 3) are also detected in the flower by combining the HPLC separation technique to its fluorescence property (Encarnación et al., 1998).

Aerial parts

Triterpenes (Figure 3) and flavonoids (Figure 3) are collected from the aerial parts of *M. jalapa*, which have a tremendous effect on several medicinal purposes (Siddiqui et al., 1994).

CHEMICAL CONSTITUENTS

Chemical analysis of different parts of *Mirabilis jalapa* Linn. revealed the presence of alkaloids, flavonoids, phenols, steroids, triterpenes (Figure 3), glycosides, tannins, saponins, and lignins. The detailed study of these compounds from TLC visualized alanine, arabinose, campesterol (Figure 4), daucosterol (Figure 4), and dopamine, d-glucan, hexacon-1-ol, indicaxanthin, C-methylabron isoflavones, n-dotriacontane, n-nonacosane, n-pentacosane, n-triacontane (Kaladhar and Nandikolla, 2010). Flowers mostly contain anthocyanins (Figure 4) and flavonoids. Several active compounds were extracted from different organs of *Mirabilis jalapa* L., including anti-fungal phenolic compounds, the ribosome-inactivating protein which is associated with the anti-viral activity, anti-microbial peptides, and retinoids that are potent inhibitors of HIV-1 reverse transcriptase. The alcoholic extract of *M. jalapa* is a possible source of active compounds against pathogenic enteric organisms (Eneji et a., 2011).

About twenty different chemical constituents have been identified from the methanolic extract of the whole plant of Mirabilis Jalapa by Gas chromatography Mass spectrometry (GC-MS) analysis. The presence of various bioactive compounds justifies the use of whole plants for various ailments by traditional practitioners. GC-MS analysis of *Mirabilis jalapa* L. revealed the existence of the ether compound-3, 3'-methylenebis (4-hydroxycoumarin (Figure 4) (17.07) ND-alpha-

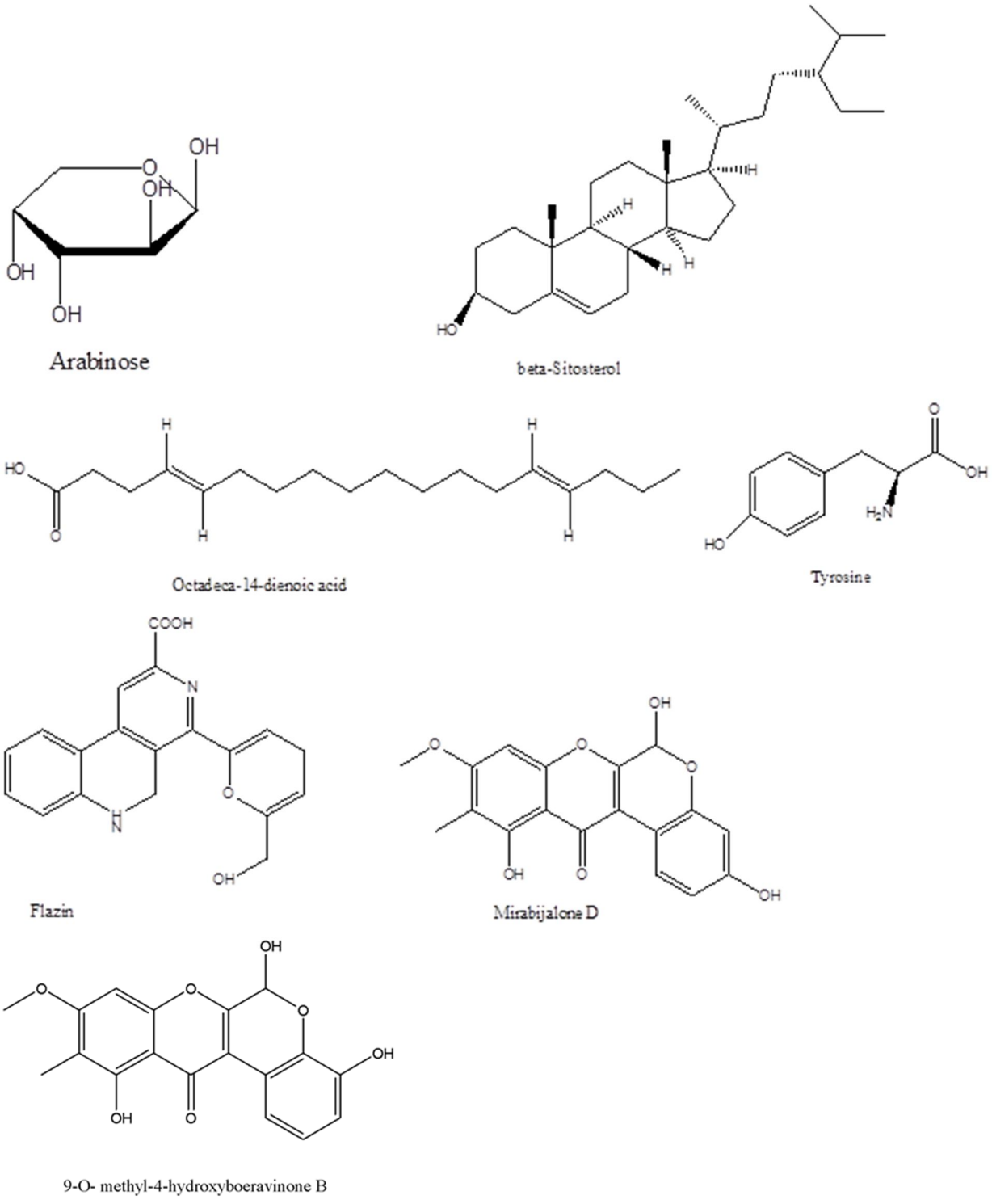
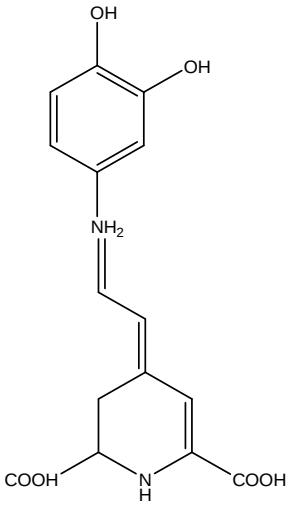
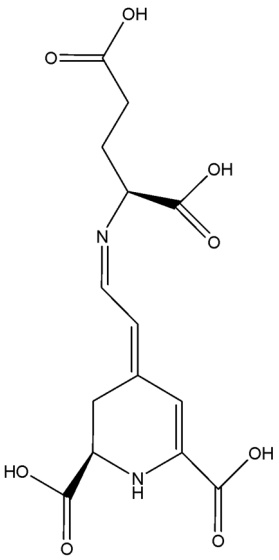


Figure 2. Chemical structure of some active constituents in *Mirabilis jalapa.*

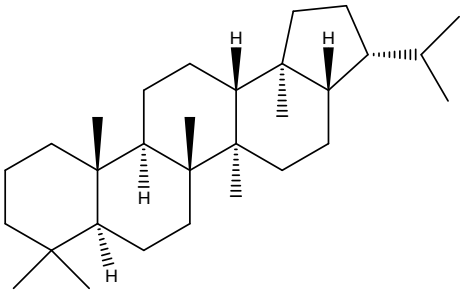
phenylyglycine (Figure 4), laminaribiitol (7.753), 3-(4-(dimethylamino) cinnamoyl) 4-hydroxycoumarin (Figure 4) (16.89), unknown (5.284), unknown (10.26). Four new rotenoids named mirabijalone A–D1 (Figure 2), boeravinone C (Figure 4) (6) and F (7), together with 9-O-methyl-4-hydroxyboeravinone B (Figure 2) and 1, 2, 3, 4-tetrahydro-1-methylisoquinoline-7 (Figure 4), 8-diol (8), were extracted from the roots of *Mirabilis jalapa*. Their



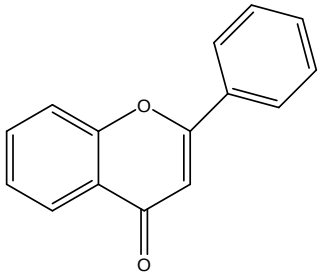
miraxanthins IV



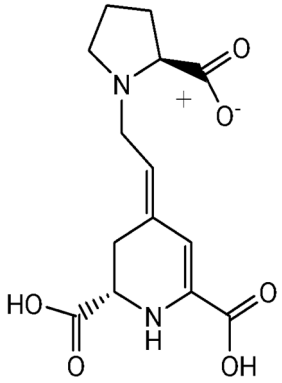
Vulgaxanthin- l



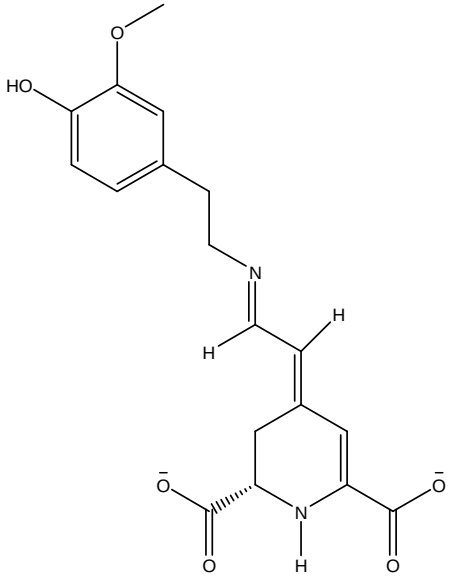
Triterpene



Flavonoid



Indicaxanthin



Betaxanthin

Figure 3. Chemical structure of some active constituents in *Mirabilis jalapa.*

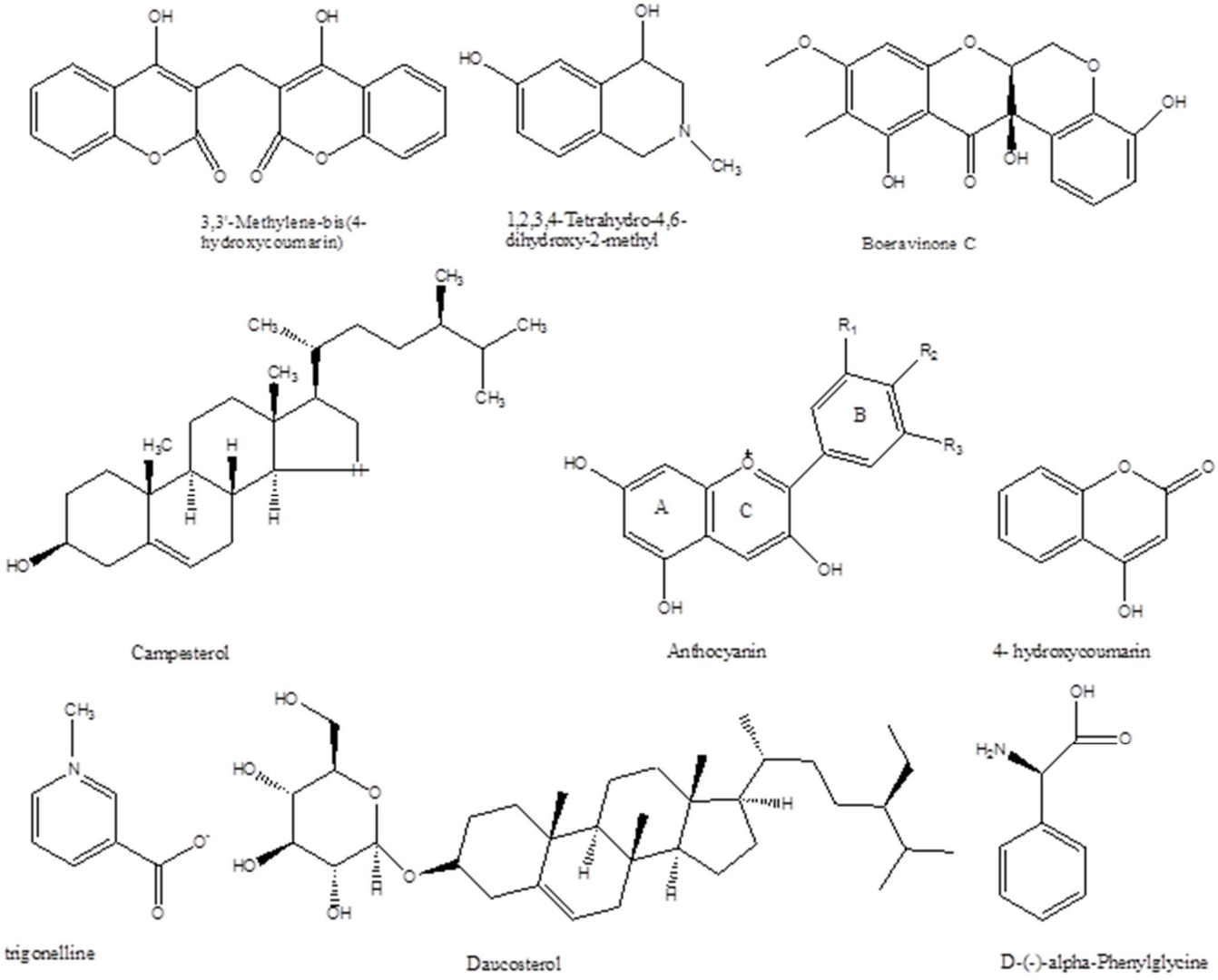


Figure 4. Chemical structure of some active constituents in *Mirabilis jalapa.*

structures were determined based on their HR-EIMS, UV, IR, 1H- and 13C-NMR (DEPT), and 2D NMR (HMQC, HMBC, NOESY) data (Rozina, 2016).

BIOLOGICAL ACTIVITIES OF *MIRABILIS JALAPA*

Anti-viral activity

Different antiviral compounds obtained from plants are active against the animal, plant, and human viruses. The antiviral activity of the leaves was tested against the HSV-I and VSV by simplified plaque reduction assay and scientifically the preliminary result exhibits to a certain extent the pharmacological activities. A group of antiviral proteins called ribosome-inactivating proteins is widely distributed in *M. jalapa* L. The extract of leaf suspension-cultured and its function with 90% saturated ammonium sulfate solution showed anti-plant viral activity comparable to that of roots and leaves of the original plant (Akintobi et al., 2011). *M. jalapa* extracts alleviated the multiplication of the Tobacco Mosaic Virus (TMV) by 50% when added to the inoculums *M. jalapa* is known to be host to two viruses: *Parietaria mottle virus* and *mirabilis mosaic virus* (Vivanco, 1999).

Anti-bacterial activity

The research showed that red-flowered *M. jalapa* plant has strong antibacterial activities and active against a wide range of microorganisms. Alcoholic extracts of *M. jalapa* has potential activities against bacteria. Antimicrobial activities of ethanolic extract of the red color

flower of *M. jalapa* have been examined *in vitro against Staphylococcus aureus* (Eneji et al., 2011). *Salmonella typhi, Escherichia coli, Bacillus ubtilis, Vibrio cholerae, Serratia marcescens* and *Pseudomonas aeruginosa*. It showed the highest inhibition against *B. subtilis* almost 47%. The plant extracts possess antibacterial activity, thus this plant is a god source of agents for bio-control and chemotherapy (Nair et al., 2005).

Antioxidant activity

The plant extract possesses modest antioxidant activity. The study reveals the immense potential of the methanol extract of aerial parts and roots for further research that aims to identify the bioactive components responsible for the antioxidant activity and elucidating their tentative mechanisms of actions. The total flavonoid content of the extract was discovered to be an active compound responsible for antioxidant activity and could serve as a free radical inhibitor (Aher et al., 2016).

Anti-diabetic activity

Nowadays, the diabetic complication is a major global health problem without any effective therapeutic approach. The ethanol extract of the root of the *M. jalapa* has anti-diabetic activity (Mahapatra and Bhaskar, 2013). Another study showed that the serum glucose, triglycerides, urea, creatinine, total cholesterol, LDL- and the activity of gluconeogenic enzyme glucose 6 phosphate levels are significantly decreased by the root extract of *M. jalapa* Linn. But the level of serum insulin, HDL-cholesterol, protein, liver, and skeletal muscle are significantly increased. Many scientists declared that the root of *M. jalapa* Linn. can be used in the treatment of type II diabetes (Sadiq et al., 2018).

Cytotoxic activity

In the brine shrimp lethality bioassay, the leaf extract of *M. jalapa* Linn. shows potential cytotoxic activity which contains ribosome-inactivating protein. The result of this preliminary study scientifically substantiates to a certain extent the anticancer activities (Zhou et al., 2012).

Anti-inflammatory activity

Inflammatory diseases are becoming common in an aging society throughout the world. The alcoholic, aqueous, petroleum ether extracts from the leaves of *M. jalapa* L. was studied for obtaining the anti-inflammatory activity by carrageenan-induced paw edema, formalin-induced paw edema, cotton pellets induced granuloma models in Wistar albino rats. All extract showed potential anti-inflammatory activity (Zhou et al., 2012). Both the test samples of carrageenan-induced rat paw edema and cotton pellet induced granuloma models to inhibit the increase in several fibroblasts and synthesis of collagen and mucopolysaccharides during granuloma tissue formation during the chronic inflammation. These experimental results have established pharmacological evidence for the folklore claim of the drug to be used as an anti-inflammatory agent (Nath et al., 2010).

Antifungal activity

The antifungal activities of *M. jalapa* were tested using the agar diffusion method against *Aspergillus niger*, *Fusarium solani, Fusarium oxysporum,* and *Fusarium granulation*. Two of the phenolic compounds isolated from *M. jalapa* L. showed antifungal activity against *Candida albicans* (Mohammed, 2012). The methanol extracts of *Mirabilis jalapa* has the potential inhibitory effect against *Aspergillus niger* and *Daedalea flavida* while do not affect *C. albicans* (Kakad et al., 2015).

Antinociceptive activity

The antinociceptive activity of a drug reduces sensitivity to painful stimuli. The literature revealed that *M. jalapa* possesses antinociceptive activity in mice, which supports its folkloric use as an analgesic. So, *M. jalapa* can be used successfully in various ethno-pharmacological preparations to treat painful disease (Walker et al., 2008).

REDUCING AGENT FOR THE PRODUCTION OF GOLD NANOPARTICLES

Basically, nanoparticles are prepared by a variety of chemical methods that are not environmentally friendly. A rapid and convenient method to reductively prepare gold nanoparticles from auric chloride using aqueous extract of ethanolic *M. jalapa* Linn. flowers. The flower extract acts as a reducing agent and encapsulating a cage for the gold nanoparticles. The production of gold nanoparticles has been done by the controlled reduction of the Au 3+ ion to Au 0. The formation of gold nanoparticles has been established by FT-IR and UV-Vis spectroscopy (Harpreet et al., 2014).

TRADITIONAL USES

From ancient times, the whole plant as well as individual parts of *M. jalapa* Linn. used traditionally to cure a variety

of human ailments. It has been reported that indigenous Mexican people use various decoctions and preparations of *M. jalapa* Linn. for the treatment of dysentery. It is used for muscular pain, diarrhea, and abdominal colic by people from different countries. The decoction of the entire plant is taken orally to treat kidney infections for dieresis (Harpreet et al., 2014). The infusion of the leaves was applied topically to reduce swelling in bone fractures or twisting. The leaves are used in inflammation, boils, Purgative and emetic properties. The leaves are crushed and mixed with salt in Sprain and bruise. Leaves are having sharp tastes and generally used for inflammation also used to apply on boils, phlegmons as a maturant. The leaves are fried in clarified butter and are fastened on the abscess. Boiled leaves are eaten to reduce body pains. The paste of leaves is used in amenorrhea and dysmenorrhea in women, skin eruption, and also has emollient property (Vanker and Dhara, 2010). In China, it has been used as traditional Chinese medicine and ethnic drug to treat diabetes, constipation, and injuries. A cosmetic powder is made in Japan from powdered seeds. In the south of Brazil, leaves were also used in traditional folk medicine to treat inflammations, pain-related diseases and as a laxative. Seeds and flowers were used to remove freckles from the skin (Bieleski, 1994). In Latin America and South Africa, roots of *M. jalapa* Linn. were traditionally used for its purgative, emetic, and cathartic properties. In Malagasy, the *M. jalapa* plant was used to treat intestinal pains. The flowers of *M. jalapa* Linn. are steeped in water to provide a crimson dye used in ancient China to prepare cakes and jellies. A cosmetic powder was also made in Japan from the powder of seeds (Sharma et al., 2001).

CONCLUSION

From time immemorial, plants have been widely used as curative agents for a variety of ailments. *M. jalapa* Linn. was widely used as a traditional, herbal based natural therapies from ancient times in different countries. Now it is a widely available weed cultivated for medicinal and ornamental purposes. It shows a wide range of ethno pharmacological activities that help to utilize the plant's medicinal values. However, there remains immense scope for further exploration of this plant and needs scientists' attention to exploit the full potential activities of this plant.

Conflict of Interest statement

Authors declare that there is no conflict of interest.

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