DOI: 10.55522/jmpas.V13I6.6727 **ISSN NO. 2320 – 7418**

International peer reviewed open access journal

Journal of Medical Pharmaceutical and Allied Sciences

Journal homepage: www.jmpas.com CODEN: JMPACO

Review article

Phytochemical composition and neuroprotective potential of *Mirabilis jalapa:* a review

Disha NS[*1], Ashok Kumar BS[2], Mamatha HS[3], Mohammed Khalid[3]

[1] Department of Pharmaceutical Chemistry, R. L. Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research, Kolar, Karnataka, India

[2] Department of Pharmacognosy, R. L. Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research, Kolar, Karnataka, India

[3] Department of Pharmaceutics, R. L. Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research' Kolar, Karnataka, India

Corresponding author: Disha NS, ✉ disha.s1215@gmail.com, **Orcid Id**: https://orcid.org/0000-0002-7704-7961

Department of Pharmaceutical Chemistry, R. L. Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research, Kolar, Karnataka, India

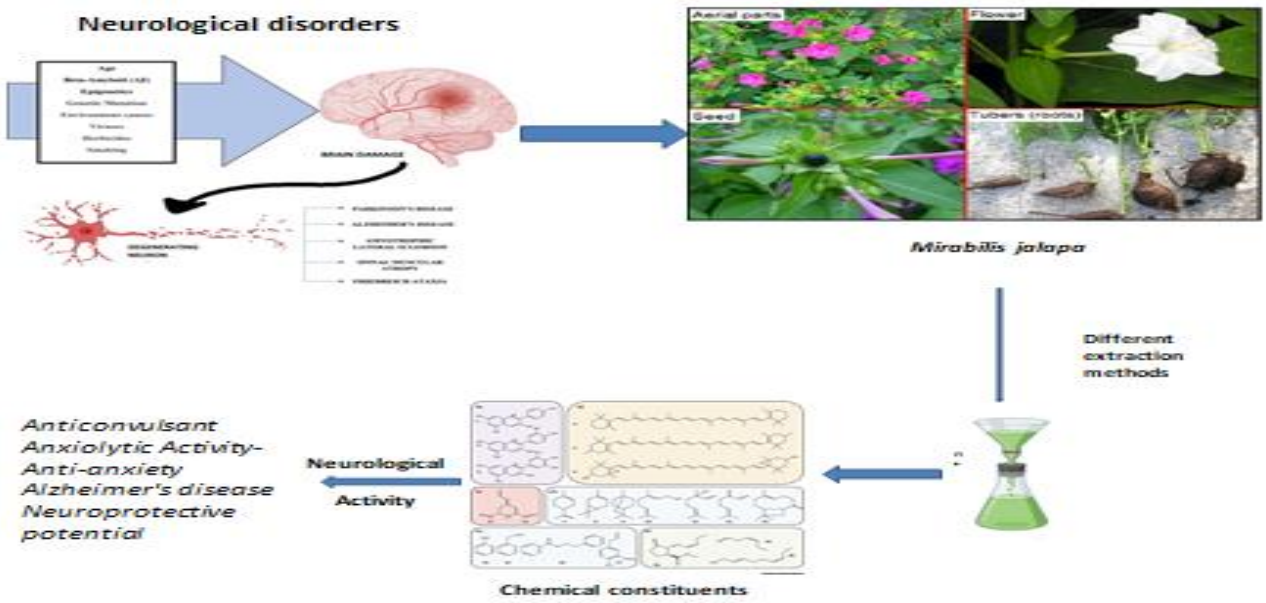
Received - 15-10-2024**, Revised** - 27-11-2024, **Accepted** - 09-12-2024 **(DD-MM-YYYY)**

Refer This Article

Disha NS, Ashok Kumar BS, Mamatha HS, Mohammed Khalid, 2024. Phytochemical composition and neuroprotective potential of *Mirabilis jalapal:* A review of its therapeutic applications in neurological disorders. Journal of medical pharmaceutical and allied sciences, V 13 - I 6, Pages - 6855 – 6870. Doi: https://doi.org/10.55522/jmpas.V13I6.6727.

ABSTRACT

Four-o'clock plant, scientifically named as *Mirabilis jalapa*, has gained significant attention for both its ornamental beauty and its medicinal properties, widely utilized as folk remedies. It is a plant grown in the warm climate as a species and showed different pharmacological effects in various therapeutic sectors such as neuroprotective and anxiolytic. Using PubMed, Web of Science Semantic Scholar and Google Scholar and the search terms *Mirabilis jalapa* phytochemicals; neuroprotection; anxiolytic effect; traditional medicine; flavonoids; alkaloids and neurological disorders literature supporting the medicinal role of *Mirabilis jalapa* were sourced.



The members of *Mirabilis jalapa* contain flavonoids, alkaloids, triterpenes leaves and saponin through which it provides possibility for the neuroprotection feature. According to research, extracts of the plant can help prevent oxidative stress, a major factor in illnesses including Alzheimer's and Parkinson's. Animal studies reveal that components from *M. jalapa* interfere with Aluminum cytotoxicity by increasing antioxidant enzyme levels, as well as decreasing oxidative damage biomolecules. In addition, the flavonoid constituent has anxiolytic effects because its extract interferes with GABAergic transmission, whereas its effectiveness is comparable to diazepam. Furthermore, the plant has exhibited anticonvulsant effect possibly due to interaction with Ca channel and Glu transmission. Thus, these studies show directions in which the plant works, indicating that it may possess valuable means to treating neurological disorders, although further clinical trials are needed to understand the exact effects of the plant in human organisms. *Mirabilis jalapa* therefore Discovered to be of great potential as natural antioxidant and neuroprotective compound as well as anxiolytic remedies.

Keywords: *Mirabilis jalapa*, phytochemicals, neuroprotection, anxiolytic, traditional medicine, flavonoids, alkaloids, therapeutic potential, neurological disorders.

INTRODUCTION

Mirabilis jalapa belongs to the Nyctaginaceae family which contains about 30 genera and 400 species of the Four-o-clock plant, also known as the Marvel of Peru. It is widely grown for the aesthetic and therapeutic purposes throughout the warm areas of America, India and some parts of Africa [1-4]. The common name of this plant is Four-o-clock, derived from the fact that its tubular, trumpet-shaped flowers bloom only at four o'clock in the afternoon and remain open all night. These flowers can be found in white, red, pink, yellow, and bi coloured with a sweet smell to attract humming birds and butterflies [5-6]. It is also cultivated to obtain large black carrot lhummingbirdsike enlarged fleshy taproot part which may weigh up to 18 kg in the required environmental conditions [7]. In folk medicine, Mirabilis jalapa was used to treat kidney infection, diuretic and tonic, purgative, and emetic [8-12]. The pharmacological activities of the plant include antimicrobial [13-15], anti-inflammatory [16-17], antidiabetic [8] and anticancer[18], antiprotozoal, anti-dermatologic. It shows the presence of tannins, alkaloids and flavonoids, glycosides terpenes saponins steroids and emodin due to which it possesses a number of medicinal activities. These bioactive compounds are the subject of current pharmaceutical investigation, where literature works describes the plant for its pharmacokinetics and pharmacodynamics, immunomodulatory and antispasmodic properties [21]. This makes Mirabilis jalapa a suitable candidate for natural compounds for formulation of new drug molecules for different therapeutic uses.

Neurological Disorders

Neurological disorders are a diverse group of conditions affecting the nervous system, including the brain, spinal cord, and peripheral nerves, with common types including Alzheimer's disease, Parkinson's disease, epilepsy, multiple sclerosis, migraine, cerebral palsy, and Guillain-Barré syndrome. These disorders can arise from various causes, such as genetic factors, environmental exposures, autoimmune reactions, degenerative processes, and metabolic disorders. Symptoms can vary widely, encompassing cognitive impairments (like memory loss), motor dysfunction (such as tremors and weakness), sensory changes (including numbness or tingling), and seizures. The diagnosis often involves a combination of medical history, physical examinations, imaging studies (like MRI and CT scans), and electrodiagnostic tests. Treatment approaches may include medications (such as anticonvulsants and immunomodulatory therapies), physical therapy, occupational therapy, and sometimes surgery, depending on the specific condition and its severity [22].

Mechanism of Action of Neurological Agents

Neuroprotective agents have the characteristic of protecting neurons from toxic insult or cellular injury, including an action or process that is directed towards the prevention or slowing of neuronal dysfunction and death. These mechanisms for the most part involve; reducing oxidant stress through the neutralization of free radicals by antioxidants, minimizing excitotoxicity by antagonizing the effects of excessive glutamate at NMDA receptors as found in memantines and finally moderation of inflammation through restraining cytokines that promote brain inflammation. Moreover, neuroprotective molecules can increase mitochondrial activity for cell energy production besides inhibiting apoptosis or stimulate the neurotrophic factors that favoured neuronal growth and recovery. Through a direct modulation of these pathways drugs target to either delay or halt neurodegeneration involved in Alzheimer's disease, Parkinson's and stroke and other conditions [23-25].

Anxiolytic Drugs

The general MOA of anxiolytic drugs primarily involves the modulation of neurotransmitter systems in the brain, particularly focusing on gamma-aminobutyric acid (GABA), serotonin, and norepinephrine. Most anxiolytic medications enhance GABAergic activity by binding to GABA-A receptors, increasing the frequency of chloride ion channel openings when GABA binds, leading to hyperpolarization of neurons. This hyperpolarization reduces neuronal excitability, producing a calming effect and alleviating anxiety symptoms. Additionally, some anxiolytics, particularly selective serotonin reuptake inhibitors (SSRIs) work by increasing serotonin levels in the brain by inhibiting its reuptake into presynaptic neurons, which enhances serotonergic transmission and

can improve mood. Serotonin norepinephrine reuptake inhibitors (SNRIs) further modulate anxiety by increasing both serotonin and norepinephrine levels. Some anxiolytics, primarily act as partial agonists at 5-HT1A serotonin receptors, balancing serotonin levels without the sedative effects Collectively, these mechanisms help alleviate anxiety symptoms by restoring balance in neurotransmitter activity in the brain[27-29].

Alzheimer's Treatment

Alzheimer's disease treatments primarily focus on improving symptoms and slowing cognitive decline by targeting key neurotransmitter systems. Cholinesterase inhibitors work by inhibiting the enzyme that breaks down acetylcholine, increases its levels in the brain to enhance memory and learning, particularly in early to moderate stages. Memantine is an NMDA receptor antagonist that affects glutamate in a way to reduce neuronal damage related to moderate to severe forms of the condition. Emerging therapies like aducanumab target beta-amyloid plaques, attempting to clear these abnormal protein deposits to slow disease progression. This multi-faceted approach aims to manage symptoms, protect neurons, and slow Alzheimer's disease progression, though it cannot cure the condition [30-32].

Anticonvulsants

Also known as antiepileptic drugs (AEDs), primarily work to prevent and control seizures by modulating neuronal excitability and neurotransmitter systems in the brain. They utilize several key mechanisms of action: sodium channel inhibitors block voltage-gated sodium channels, stabilizing neuronal membranes and reducing seizure activity; calcium channel inhibitors inhibit T-type calcium channels, decreasing excitatory neurotransmitter release; GABAergic drugs enhance the effects of gamma-aminobutyric acid (GABA), the primary inhibitory neurotransmitter, thereby increasing inhibitory signaling; and glutamate inhibitors reduce the action of glutamate, an excitatory neurotransmitter, by blocking its receptors. Collectively, these mechanisms help to stabilize neuronal activity and effectively manage seizures in individuals with epilepsy [33, 34].

This review aims at reviewing the studies on the therapeutic efficacy of *Mirabilis jalapa* especially concerned with the effects of the extract on neurological diseases based on neuroprotection and anxiolytic effects. The plant has been used as traditional medicine in the management of several diseases and it's have active ingredients like flavones, flavonoids, alkaloids and other active compounds with some antioxidant, anti-inflammatory and neuroprotective activities. The current article synthesizes literature from PubMed, Google Scholar & Web of Science to reveal the prospect of *Mirabilis jalapa* in managing neuropathological disorders such as Alzheimer's and Parkinson's diseases besides its anxiolytic potency.

Vernacular Names [35-37].

Table 1: list of vernacular name

State	Common Name
Telugu	Chandrakanta
Assamese	Gophuligopal; Sarpamani;
Bengal	Krishnakeli,
English	Four o' clock, Marvel of
Gujrati	Gubbaji
Hindi	Gul-abbas
Kannada	Sanjamalligie, Chandramalligie;
Punjabi	Gulabbas;
Tamil	Andhimalligai
Sanskrit	Krishnakeli
Oriya	Rangai
Malayalam	Antmalari
Marathi	Gulbas
Persian	Gul-i-abbasa

Taxonomy

Table 2: Taxonomy of *Mirabilis jalapa*

Kingdom	Plantae
Subkingdom	Viridiplantae
Infrakingdom	Streptophyta
Super division	Embryophyta
Division	Tracheophyta
Subdivision	Spermatophytina
Class	Magnoliopsida
Superorder	Caryophyllanae
Order	Caryophyllales
Family	Nyctaginaceae
Genus	Mirabilis
Species	Mirabilis jalapa

Synonyms and Other Names

Jalapa congesta, Jalapa officinalis, Mirabilis ambigua, Mirabilis jalapa var. jalapa, Mirabilis jalapa subsp. lindheimeri, Mirabilis lindheimeri, Mirabilis jalapa var. lindheimeri, Mirabilis pedunculata, Mirabilis procera Bertol, Mirabilis planiflora, Mirabilis pubescens, Mirabilis suaveolens, Mirabilis xalapa and Nyctagojalapae Nyctago hortnesis Dum. Cours. Nyctago jalapa(L.) DC, Nyctago versicilor Salisb"

M. dichotoma Linn. (in Brazil), M. dichotoma Linn. M. lindheimeri Linn., and M. longiflora Linn. (in tropical America), and M. odorata Linn[41-43].

Phytochemical Characteristics

Physico chemical evaluation of the ethanolic extracts of Mirabilis jalapa leaf revealed that the percent w/w of total ash was 15.15 % and Acid insoluble ash was 4.57 % while the Water soluble ash was fetched 3.75 % and water soluble extractive value was 26.22 % and alcohol soluble extractive value and ether soluble extractive value were 21.81 % & 24.94

The physicochemical parameter of the powder of the whole Mirabilis jalapa plant were: loss on drying 12.41% ± 0.005, total ash 11.81% ± 0.001, water soluble ash 5.06% ± 0.001, acid insoluble ash 0.41% ± 0.001, alcohol soluble extractive value 11.02% ± 0.007, water soluble materials 18.63% ± 0.007, and ether soluble materials [46].

The determined iodine value was 80 and the saponification value was 172.

A from seeds 3% of oil was obtained, and the oil has a density of 0.70 g/ml, surface tension 26.10 dynes/cm and viscosity

169.5 millipoise at 20.5 °C.

Table 3: The morphological features of *Mirabilis Jalapa*

Parts	Images	Macroscopic features
Plant		A herbaceous perennial plant that grows to a height of 30-75 cm with thick, fleshy stems.
Leaf		Opposite leaves, 3.5-7.5 cm wide and 5-10 cm long, are unequal in shape, ranging from ovate to subcordate.
Flower		Flowers are shortly stalked, funnel-shaped, and found in clusters, each subtended by an involucre of five ovate, connate bracts. The flowers may be striped or blotched fragrant colors, including white, yellow, purple, or red. The perianth is funnel-shaped with five lobes, while the stamens number between 3 and 6 and are exserted. The anthocarps are globose and turn black when ripened
Seeds		The seeds are olive, brown or black and are about twice the size of a peppercorn.
Tubers		The roots are thick, tuberous and swollen at the nods, and can be 10 cm or more in diameter.

Chemical constituents

Flowers

Many betaxanthins pigments (indicaxanthin, vulgaxanthin-I, miraxanthin-I, -II, -III, -IV, -V and -VI) were identified in the flowers by combining HPLC separation techniques to its fluorescence property of *Mirabilis jalapa*[48-51].

Aerial parts: Triterpenes, flavonoids, Stigmasterol, Beta-sitosterol, ursolic acid, oleanolic acid and brassicasterolare present[52].

Seeds

A fatty acid was identified as a minor constituent in the seed oil and was labelled as 8-cis-11, 14-hydroxy-octadeca-dienoic acid 1. Arginine, glycine, Histidine, threonine, tyrosine, asparatic acid and glutamic acid were found in seeds 2. The seeds cotyledons D-glucan reported as a polysaccharide containing 38 glycosyl units 2 of β-sitosterol, β-amyrin/β-sitosterol-D-glucosid and/β-amyrin-3-O-α-L-rhamnogycol- O/β-D-glucoside 4,5were extracted from seeds two newly identified antimicrobial peptides also isolated from seeds and characterized including Mj-AMP-1 and Mj-AMP-2 [53-54].

Leaves

Flavonoids include quercetine and C- glycosyl flavonoid in leaves. Tricosan-12-one, n-hexacosanal, β-sitosterol was extracted out of the leaves and tetracosanoic acid out of the tartaric acid, citric acid, these molecules include leucuine, valine, tryptophan, and alanine and glycine were determined qualitatively using paper chromatography. D-pinitol, an o-methyl inositol. Succesively, fructanes as Fru 1, 6 bisphosphate (Fru 1, 6 P 2) in the range of 5001-2001 was cited as a major carbohydrate in leaves. Bioaasay solvent partitioning of the methanol extract of leaves and stems fixed was based on the isolation of an active polyphenolic amide N-trans-feruloyl-4'-O-methyldopamine.

Roots

The root is the largest source of biological content for searches by billions of users around the world. In *Mirabilis jalapa Linn.* The roots contain 3% resin, trigonelline the wealth of India: raw materials, 1998 carbohydrate which after hydrolysis produces galactose and arabinose. By using column chromatography and NMRspectroscopy and mass spectroscopy and astragaloside-II flazin among them are phytoconstituents are isolated from root Source of phytoconstituents many phytoconstituents are isolated from root Permission granted to use this image Phytochemicals come under various classes of natural products; alkaloids; flavonoids; phenols tannins and terpenoids. An anti-plant virus and also proposes a viral protein active against mechanical transmission of. Plant viruses was isolated and purified from roots using double precipitation with ammonium sulfate and exchange through an ion-exchanger Chromatography. Rotenoid mirabijalone A, B, C and D along with 9-O-methyl-4 hydroxyboeavinone -B and 1,2,3,4-tetrahydromethylisoquinoline-7,8-diol were isolated from the root of C. muconata. Boeavinone, urea, glycerin monoeicosate and betaethyl sitosterol were extracted from the 75% ethanol roots extract. According to the study the people should take in *Mirabilis jalapa* root may prevent the complication of high blood glucose caused by diabetes

Neurological Activity in *Mirabilis jalapa*

Neuroprotective potential

This article focuses on the effects of administering Mirabilis jalapa flower extracts in addressing this problem of Aluminium induced neurotoxicity in Wistar rats. Neurotoxicity was induced with aluminium hydrochloride that damages the brain and has linkages to neurodegenerative diseases such as Alzheimer's. Various parts/ fractions of *Mirabilis jalapa* plant petroleum ether, acetone, methanol and aqueous fraction was tested at 250mg/kg and 500mg/kg. The results of the present work revealed that aluminium increased the serum level of ALT, AST, nitric oxide and TBARS and depressed the SOD and glutathione in rat. However, the extract of *Mirabilis jalapa* reduced the antioxidant enzymes significantly on these marker of oxidative stress and cellular damage. These outcomes suggest that the extracts can prevent the damage of brain cells and oxidative stress and enhance the antioxidant system, which could make *Mirabilis jalapa* a candidate for the treatment of neurodegenerative diseases related to aluminium toxicity.

Anti-anxiety

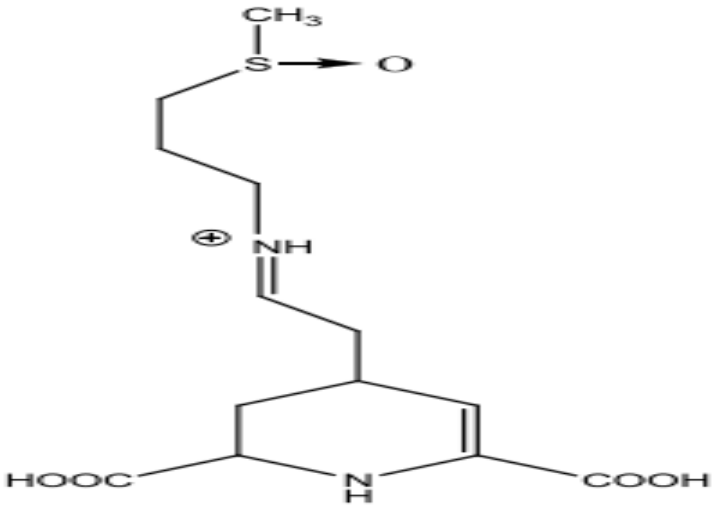
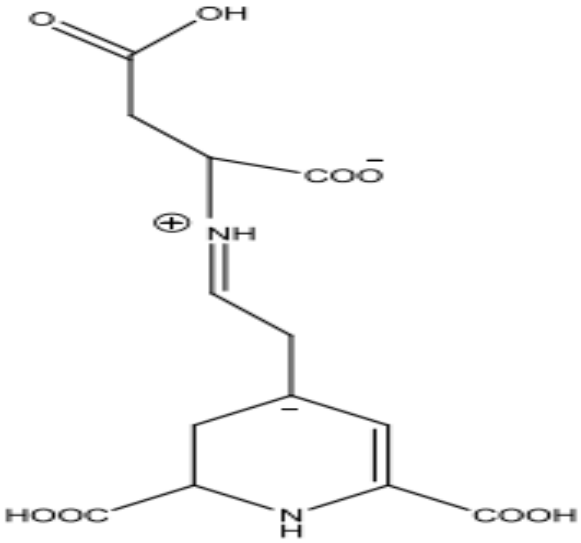
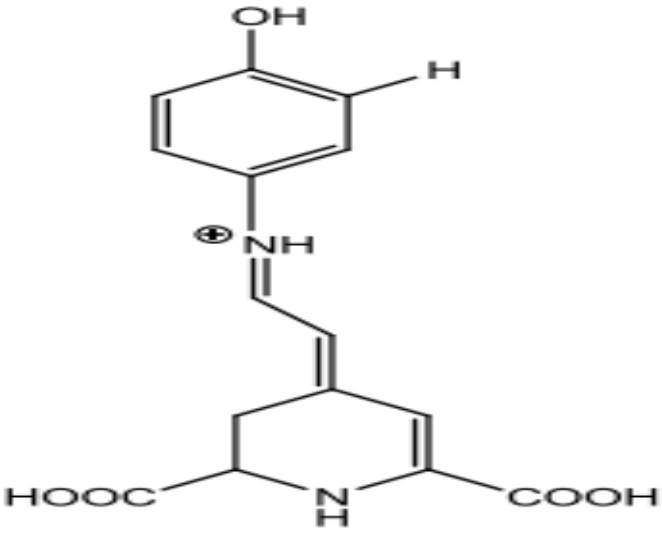
The work aims at investigating the stress alleviation effects of Mirabilisjalapa on Drosophila melanogaster (fruit fly) influenced from oxidative stress by MTX, a known stress agent. The research involved four groups of flies: The animals were divided into a control group, a group given MTX only, a group receiving both MTX and *M. jalapa* extract, and a group which received only the plant part of *M. jalapa.* Stress-induced flies had higher levels of oxidants; they had heightened CAT and SOD levels which indicate oxidants. Treatments using *M. jalapa* extract lowered the level of these enzymes which indicates that the extract helps in reversing the effects of stress through decreasing ROS. The phytochemical screening brought to light that the plant contained flavonoids, phenols, alkaloids, and tannins which assist the antioxidant property of the plant. They make a case that *M. jalapa* can be used as an anti-stress and call for more research on the plant for other related medicinal uses.

Alzheimer's disease

Mirabilis jalapa used in the section on Ethnomedicine is known to possess memory-improving effects. The plant has been utilized in different traditional systems of medication in Africa, including the Nigerian, to cure senile dementia and neurodegenerative diseases including AD. Although it is not clarified how it operates, its position alongside the plant with pharmacologic effects involving anti-cholinesterase impact on cognitive function and

memory consolidation endorses it. ALTOGETHER, similar to many other medicinal plants there is an urgent need to establish scientific evidence concerning the efficiency and the bioactive compounds present in the plant for the treatment of AD.

Table 3: Chemical structure of some active constituents in flower of *Mirabilis jalapa*

Chemical name	Structure
Miraxanthin-I	
Miraxanthin-II	
Miraxanthin-III	

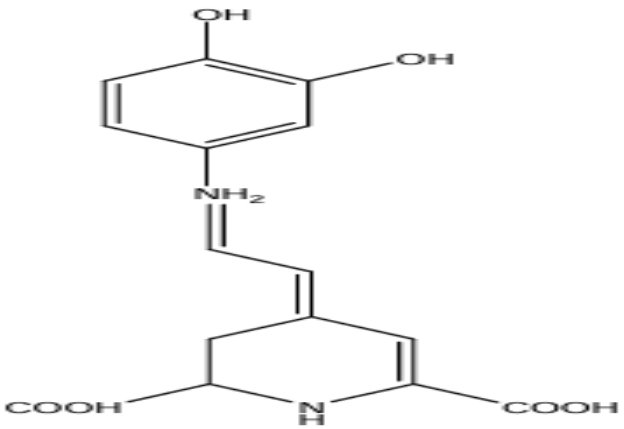
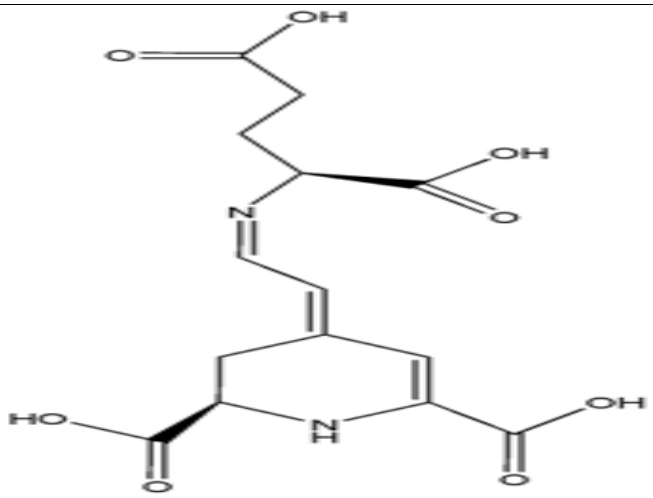
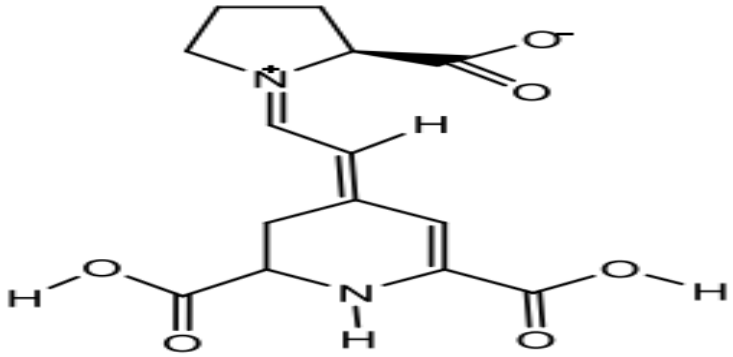
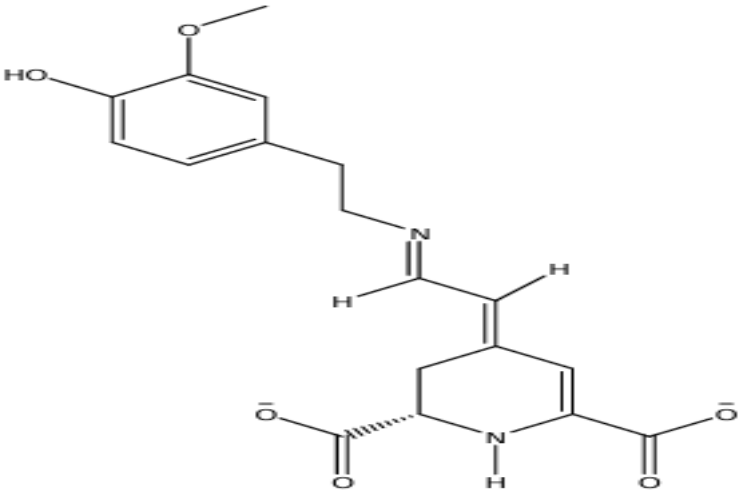
Miraxanthin-IV	
Vulgaxanthin-I	
Indicaxanthin	
Betaxanthins	

Table 4: Chemical structure of some active constituents in Aerial parts of *Mirabilis jalapa*

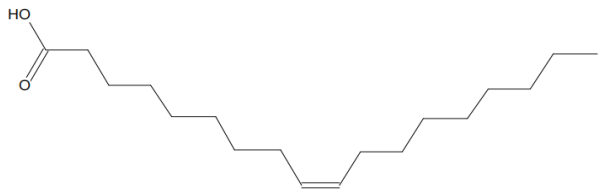
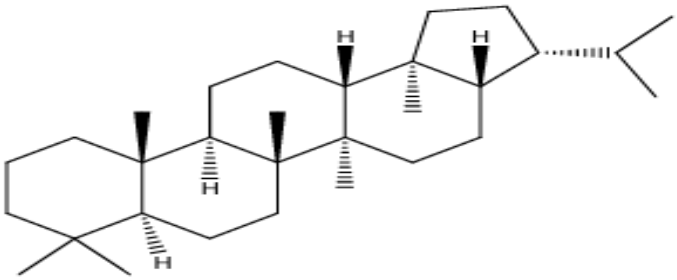
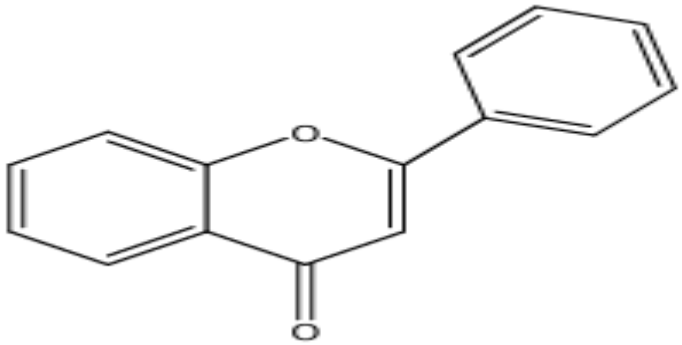
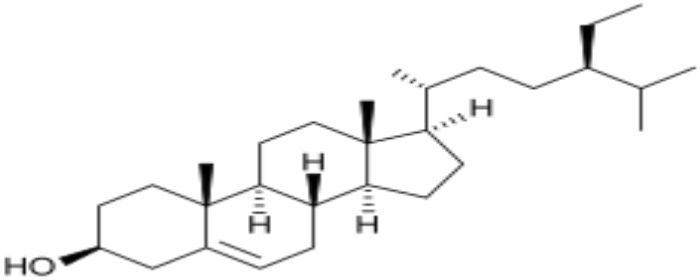
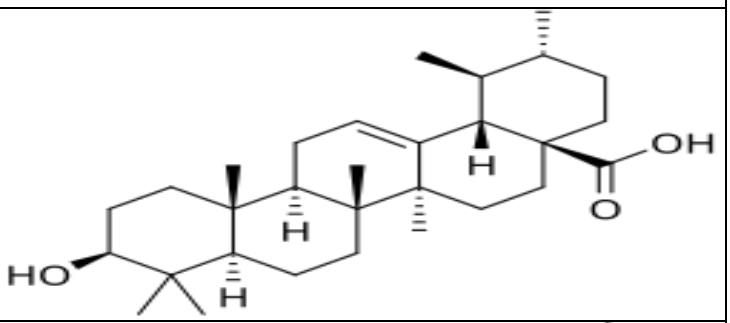
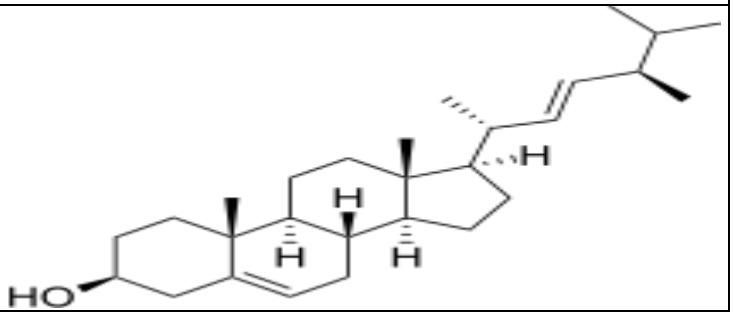
Chemical name	Structure
Oleanolic acid	
Triterpenes	
Flavonoids	
Beta-Sitosterol	
Ursolic Acid,	
Brassicasterola	

Table 5: The active constituents in Seed of *Mirabilis jalapa*

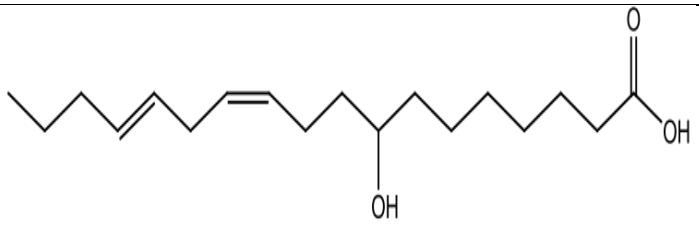
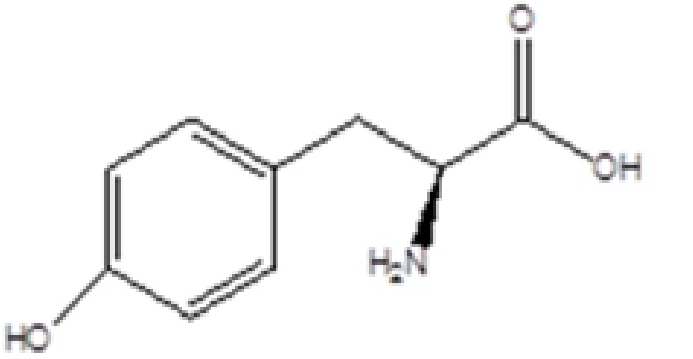
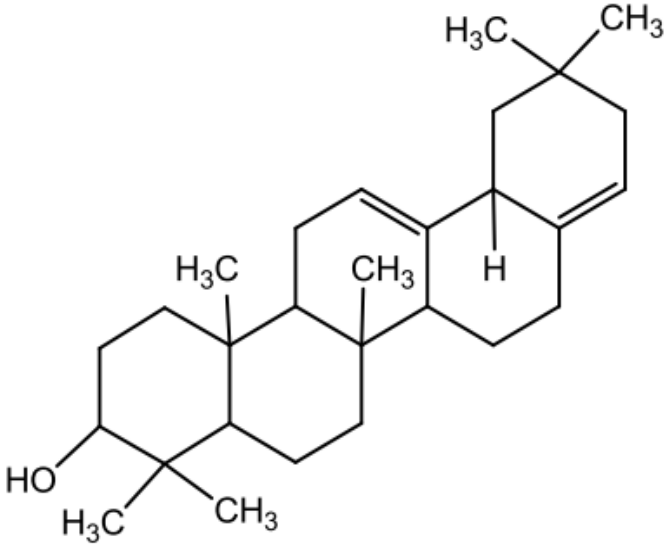
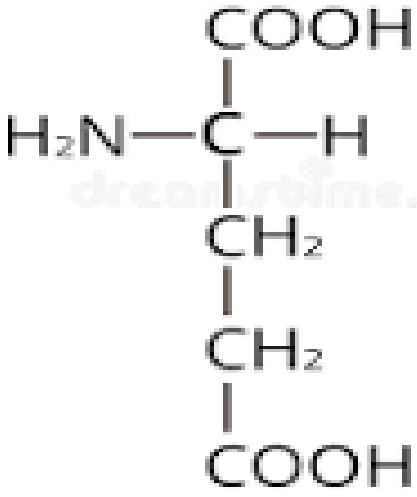
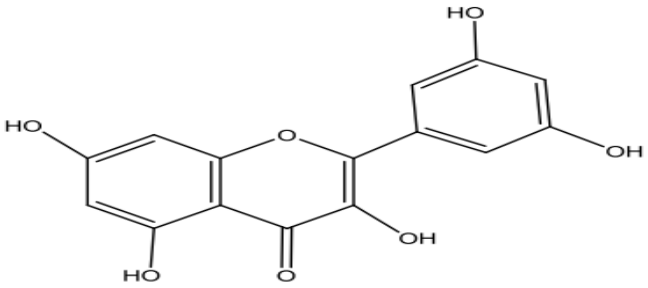
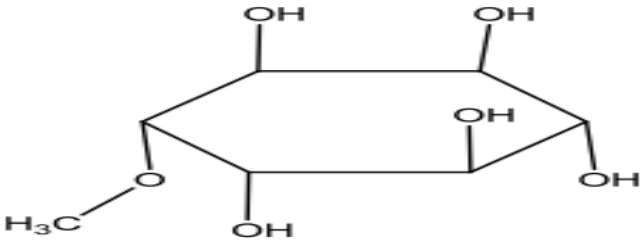
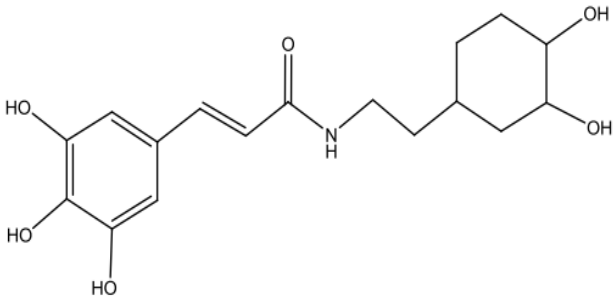
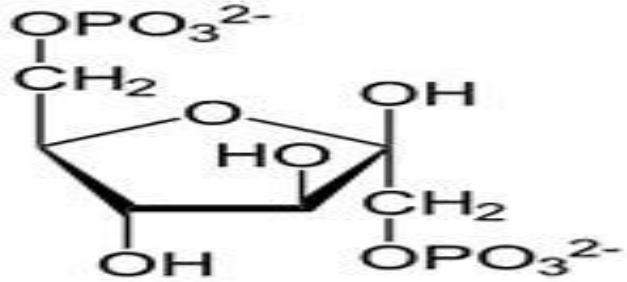
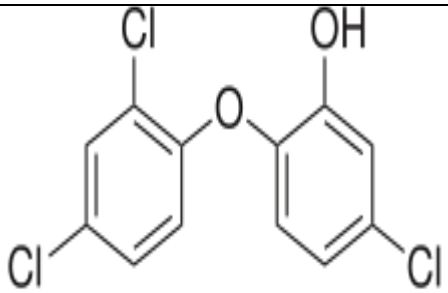
Chemical name	Structure
8-cis-11,14-hydroxy-octadeca-dienoic acid	
tyrosine	
β-amyrin	
Glutamic acid	

Table 6: Chemical structure of some active constituents in leaves of *Mirabilis jalapa*

Chemical constituents	Structure
Quercetine	
O-methyl inositol	
Polyphenolic amide N-trans-feruloyl-4'-O-methyldopamine	
Fru 1, 6 bisphosphate	
Tetracosanoic acid	
Tricosan-12-one,	

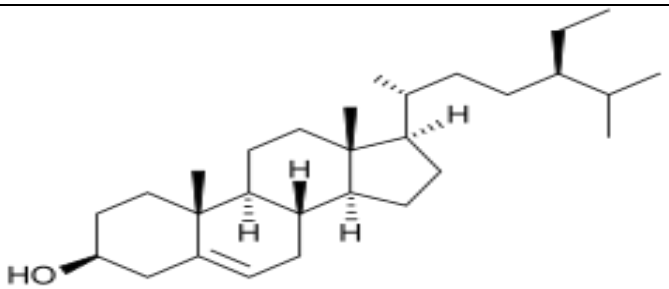
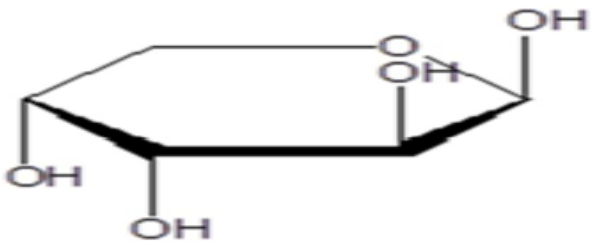
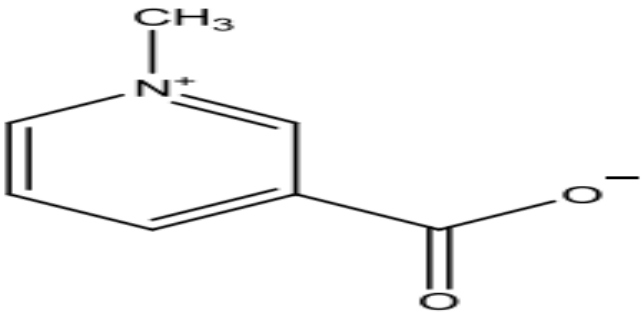
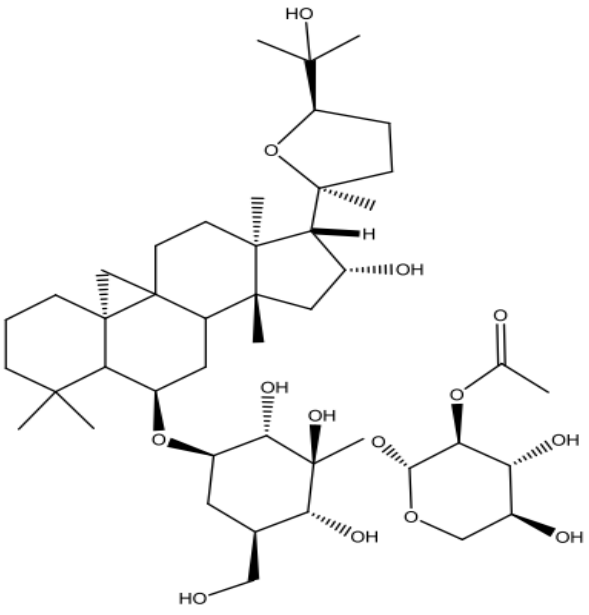
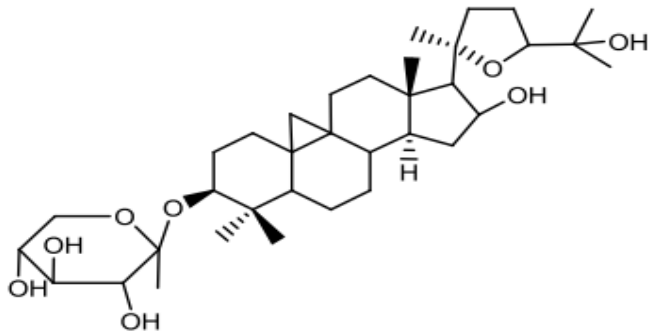
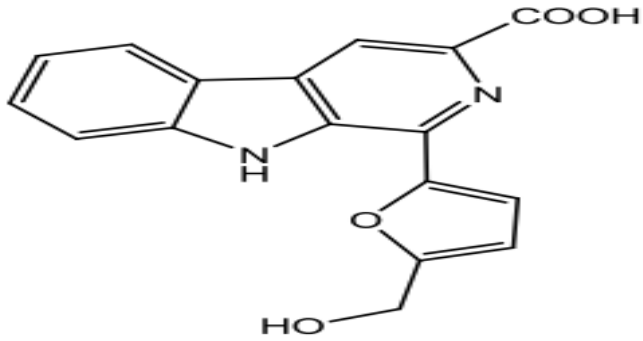
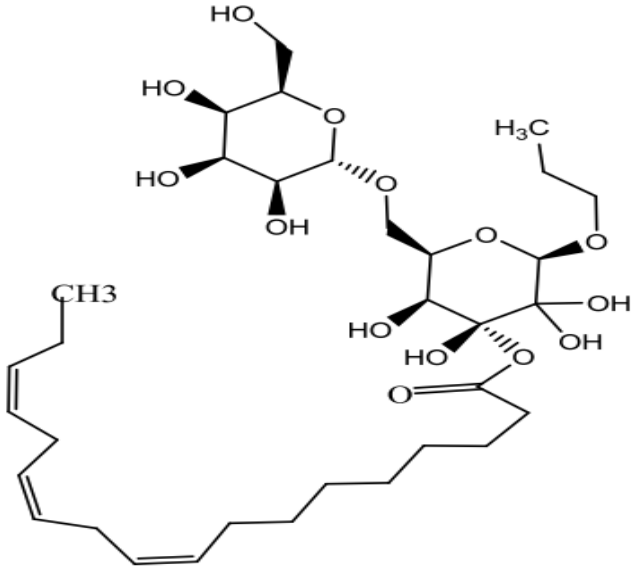
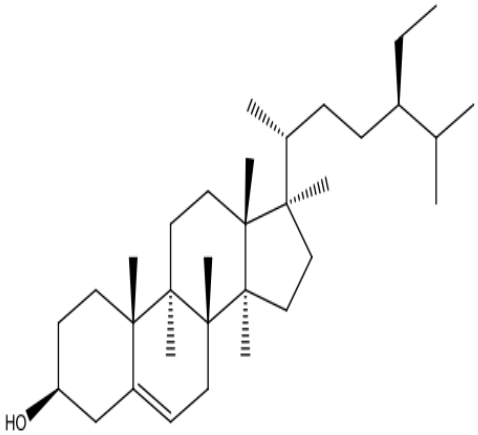
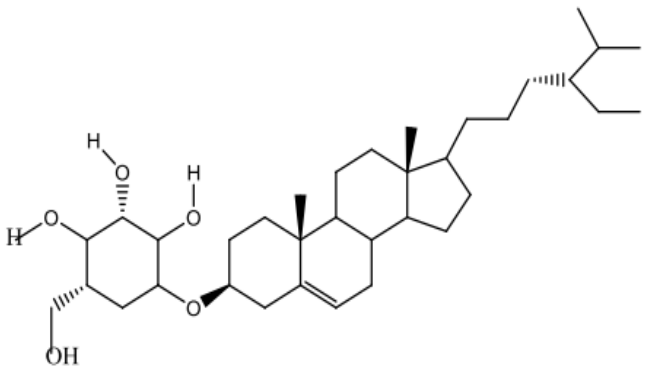
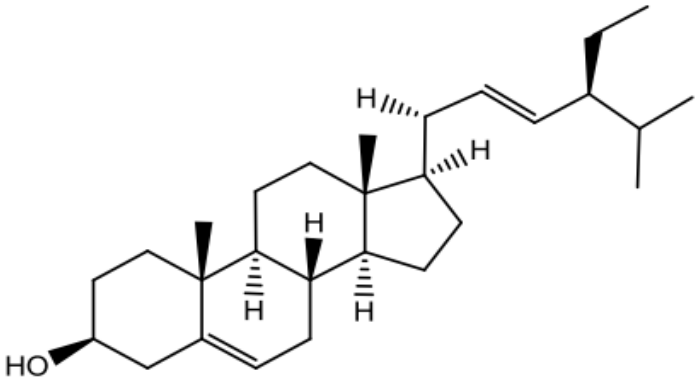
n-hexacosanal	
β-sitosterol	

Table 7: Chemical structure of some active constituents in Roots of *Mirabilis Jalapa*

Chemical name	Structure
Arabinose	
Trigonelline	
Astragaloside-II	

Astragaloside-IV	
Astragaloside-VI	
4'-Hydroxy-2,3-Dihydroflavone-7-Beta-D-Glucopyranoside, Gingerglycolipid-A	
3,4-Dihydroxybenzaldehyde, P-Hydroxybenzaldehyde, *B*-Sitosterol	

Daucosterol	
Stigmasterol	

Anxiolytic Activity-

This article focuses on the anxiolytic effect of Mirabilis jalapa through its methanolic extract with secondary metabolites including flavonoids, phenols, alkaloids, and tannins. www-naturaldatabase.com indicates that flavonoids isolated specifically quercetin interact with GAB receptors in the brain and dampen neuronal activity, even as do diazepam anxiolytics. Metho clinical evidence of experimental procedures such as Elevated Plus Maze and Open Field Test reveals that rats treated via the extract had manifested increased anxiety like behavior as suggested by the increased number of time taken to spend in the open arms and increased exploration, as compared to the normal rats. To this effect, the present study provides evidence showing that the ethanol extract of Mirabilis jalapa possesses anxiolytic effects, therefore proposing this plant as a possible replacement for pharmacological treatments for anxiety disorders in humans.

To measure the ability of Mirabilis jalapa as an anxiolytic agent, the authors used the Elevated Plus Maze (EPM) and Open Field Test (OFT). The ethanolic extracts, especially at the higher dose of 400mg/kg have raised the time spent in the open arms of EPM and improved the locomotor activity in the OFT, thereby suggesting anxiolytic effect similar to diazepam. These results propose the possibility that the plant's extract, which is rich in flavonoids, may have an anxiolytic effect or work through GABAergic mechanisms. In conclusion, Mirabilis jalapa has potential benefit for the treatment of anxiety and convulsive disorders, though additional research is necessary to determine the bioactive components and the pathways responsible for the clinical effects.

Anticonvulsant

Considering anticonvulsant activity, and further investigations in experimental models, Mirabilis jalapa can be looked forward for its naturality to manage neurological disorders. The anticonvulsant activity of ethanolic extracts of Mirabilis jalapa was tested using the Maximal Electroshock (MES) together with the Pentylenetetrazol (PTZ) seizure tests. Comparing both models, the extract at doses of 200mg/kg and 400mg/kg showed protection against seizures especially the 400mg/kg dose as it delays the onset of seizure and reduces the tonic hind limb extension. These effects are similar to the reference antiepileptic drug Phenytoin so that MJ might suppress seizures acting via various mechanisms, including inactivation of calcium channels or blockade of the NMDA receptor-dependent release of endogenous glutamate and facilitation of GABAergic neurotransmission. Possible reasons for such an effect are the content of flavonoids, phenolic compounds, and alkaloids in the plant extract.

The research work entitled "Anticonvulsant activity of aqueous extract of *Mirabilis jalapa Linn*. Roots in experimental animals" evaluates the antiepileptic effect of the root extract employing chemical convulsion models including; maximal electroshock (MES) and pentylenetetrazol (PTZ). The outcomes revealed a decrease in seizure length/symptoms similar to conventional medications such as phenytoin and diazepam, due to

possible pointed alterations of neurotransmission by some bioactive ingredients within the plant extract including the alkaloids and flavonoids. This bears the modern scientific backing to its traditional function as an antiepileptic and general neurological condition remedy.

CONCLUSION

it was found that Mirabilis jalapa possess significant therapeutic importance in treating neurological disorders because of its multitude of phytochemical profile such as alkaloids, flavonoids, terpenoids and phenolic compounds. These bioactive constituents play a vital role for the therapeutic effects such as antioxidant, anti-inflammatory, neuroprotector activity, anxiolitic and anticonvulsive activity, which are important for the management of neurodegenerative diseases like Alzheimer and Parkinson and anxiety, epilepsy, etc. Previous animal investigations have shown that this plant has antioxidant, anti-neuro-inflammatory and neuroprotective effects and ability to influence the levels of neurotransmission. Yet, to unlock its full therapeutic application, significant spell of pharmacology, including trials, have to be completed for the appropriate discovery of the usage and effectiveness on the human body, and safety profile before it makes its way into contemporary medicine.

REFERENCES

1. Kurian JC, Mutatkar RK, Samraj E, 2013. Plants that heal. 1st ed. Pune, India: P.H. Lall, at and for the owners of Oriental Watchman Publishing House, Pune 1 pages 214-215.

2. NidavaniRB, Mahalakshmi AM, 2014. An ethanopharmacological review of four O' clock flower plant, Mirabilis jalapa Linn. Journal of Biological & Scientific Opinion. 2(6), Pages 344-348. Doi: 10.7897/2321-6328.02679.

3. Khurian JC, 2003. Plants that heals. Fifth edition, Vol. 1, Oriental watchman publishing house, Pune. Pages 214-215. Plants that Heal - J. C. Kurian - Google Books.

4. Sharma HK, Chhangte L, Dolui AK, 2001. Traditional medicinal plants in Mizoram, India. Fitoterapia. 72, pages 146-161. Doi: 10.1016/s0367-326x(00)00278-1.

5. Agunbiade SO, 2011. Antimicrobial evaluation and phytochemical analysis of leaf extracts of Mirabilis jalapa against some human pathogenic bacteria. Medicine, Environmental Science. Doi: 10.3923/tmr.2007.108.112.

6. Dimayuga RE, Virgen M, Ochoa N, 1998. Antimicrobial Activity of Medicinal Plants from Baja California Sur (México). Pharmaceutical Biology. 36(1), Pages 33-43. https://doi.org/10.1076/phbi.36.1.33.4625.

7. Kusamba C, Byamana K, Mbuyi WM, 1991. Antibacterial activity of Mirabilis jalapa seed powder. Journal of ethnopharmacology. 35(2), Pages 197-199. Doi: 10.1016/0378-8741(91)90073-m.

8. Singh M, Kumar V, Singh I, et al, 2010. Anti-inflammatory activity of aqueous extract of Mirabilis jalapa Linn. Leaves. Pharmacognosy research. 2(6), Pages 364-367. Doi: 10.4103/0974-8490.75456

9. Nath LR, Manjunath KP, Savadi R v, et al, 2010. Anti-inflammatory activity of mirabilis jalapa linn. Leaves. Journal of basic and clinical pharmacy. 1(2), Pages 93-96. Doi: 10.4103/0974-8490.75456.

10. OladunmoyeM. K. Antioxidant, 2012. free radical scavenging capacity and antimicrobial activities of Mirabilis jalapa. Medicine, Environmental Science, Chemistry. Doi: https://doi.org/10.5897/JMPR09.281.

11. Hajji M, Jarraya RM, Lassoued I, et al, 2010. GC/MS and LC/MS analysis, and antioxidant and antimicrobial activities of various solvent extracts from Mirabilis jalapa tubers. Process Biochemistry. 45, Pages 1486-1493. Doi:10.1016/j.procbio.2010.05.027.

12. Rumzhum NN, Rahman MM, Islam MS, et al, 1970. Cytotoxicity and Antioxidant Activity of Extractives from Mirabilis jalapa. Stamford Journal of Pharmaceutical Sciences. 1(1), Pages 85-88. Doi: https://doi.org/10.3329/sjps.v1i1.1814.

13. Maxia A, Sanna C, Salve B, et al, Inhibition of histamine mediated responses by Mirabilis jalapa: confirming traditional claims made about antiallergic and antiasthmatic activity. Natural product research. Doi: 10.1080/14786410802632804.

14. Ganapathy V, Graham GD, DiBonaventura MD, et al, 2015. Caregiver burden, productivity loss, and indirect costs associated with caring for patients with poststroke spasticity. Clin. Interv. Pages 1793–1802. Doi: 10.2147/CIA.S91123.

15. Feigin VL, Vos T, Nichols E, et al, 2020. The global burden of neurological disorders: Translating evidence into policy. Lancet Neurol. 19, Pages 255–265. Doi: 10.1016/S1474-4422(19)30411-9.

16. Wan M, He J, Huo J, et al, 2023. Intermediate-Length GGC Repeat Expansion in NOTCH2NLC Was Identified in Chinese Patients with Amyotrophic Lateral Sclerosis. Brain Sci. Pages 13:85. Doi: 10.3390/brainsci13010085.

17. Zhou Q, Tian M, Yang H, 2022. Adult-Onset Neuronal Intranuclear Inclusion Disease with Mitochondrial Encephalomyopathy, Lactic Acidosis, and Stroke-Like (MELAS-like) Episode: A Case Report and Review of Literature. Brain Sci. 12, Pages 1377. Doi: 10.3390/brainsci12101377.

18. Kishi, T., et al. (2018). The efficacy and safety of memantine for the treatment of Alzheimer's disease. Expert Opin Drug Saf. 14, Pages 1809-1824. Doi: https://doi.org/10.1080/14740338.2018.1524870.

19. Wolfgang Löscher , Henrik Klitgaard, Roy E Twyman, 2013. New avenues for anti-epileptic drug discovery and development. Nature Reviews Drug Discovery. 12(9), Pages 703-716. Doi: 10.1038/nrd4126.

20. Perucca, Torbjörn Tomson, 2014. The pharmacological basis of the treatment of epilepsy. Pharmacology & Therapeutics. 142(3), Pages 311-329. Doi: 10.1016/S1474-4422(11)70047-3.

21. Kwan P, Brodie M.J, 2000. Early identification of refractory epilepsy. New England Journal of Medicine. 342(5), Pages 314-319. Doi: 10.1056/NEJM200002033420503.

22. Nidavani RB, Am M, 2014. An Ethanopharmacological Review of Four O' Clock Flower Plant (Mirabilis jalapa Linn.). J Biol Sci Opin. 2(6) Pages 344-348. Doi: 10.7897/2321-6328.02679.

23. Rozina R, 2016. Pharmacological and biological activities of Mirabilis jalapa L. Int J Pharmacol Res. 6(5), Pages 160-168. Doi: 10.7439/ijpr.

24. Selvakumar P, Kaniakumari D, Loganathan V, 2012. Phytochemical screening and antioxidant activity of red flowered Mirabilis jalapa leaf in different solvents. International Journal of Pharma and Bio Sciences. 3(4) pages 440-446.

25. Hanani E, Prastiwi R and Karlina L, 2017. Indonesian Mirabilis jalapaLinn: A pharmacognostical and preliminary phytochemical investigations. Pharmacogn J. 9(5), Pages 683-688. Doi: 10.5530/pj.2017.5.108.

26. Devi YU, Zaidi HR and Saiprakash PK, 1983. Composition and characteristics of Mirabilis jalapa seed oil. Fette, Seifen, Anstrichmittel 85(12) pages 486-487. Doi: https://doi.org/10.1002/lipi.19830851210.

27. Encarnación RD, Virgen M, Ochoa N, 1998. Anti-microbial activity of medicinal plants from Baja California Sur (MÉXICO). Pharm Biol. 36(1), Pages 33-43. Doi: 10.1076/phbi.36.1.33.4625.

28. Drunkler DA, Fett R, Luiz MTB, 2006. Avaliacao da estabilidade de betlains em extrato de beterrata (beta vulgaris l.) Com α ¯, β ¯e γ ¯ciclodextrinas. B.ceppa, Curitiba200. 24(1), Pages 259-276. Doi: 10.5380/cep.v24i1.5272.

29. Piattelli M,Minale L and Nicolaus RA, 1965. Pigments of centrospermae-V.: Betaxanthins from Mirabilis jalapa L. Phytochemistry 4(6), Pages 817-823. Doi: https://doi.org/10.1016/S0031-9422(00)86258-5.

30. Ghosh A, Nayak A, Banerji J, 2014. Chemical characterization of seed proteins of Mirabilis jalapa L. (Nyctaginaceae). International Journal of Food Properties 17(3), Pages 559-569. Doi: 10.1080/10942912.2011.642632.

31. Patel RG, Patel VS, 1985. Studies on Mirabilis jalapa (Four O'clock plant) seed oil. Fette, Seifen, Anstrichmittel. 87(1), Pages 7-9. Doi: 10.1002/lipi.19850870104.

32. Behari M, Andhiwal CK and Streibl M, 1976. Some chemical constituents of the leaves of Mirabilis jalapa L. Collect Czech ChemCommun 41, Pages 295-298. Doi: 10.1135/CCCC19760295.

33. Lai GF, Luo SD, Cao JX, et al, 2008. Studies on chemical constituents from roots of Mirabilis jalapa. ZhongguoZhong Yao ZaZhi 33(1), Pages 42-46.

34. Brown T, Smith J, 2024. Anxiolytic effects of *Mirabilis jalapa* methanolic extract: Flavonoids and GABAergic mechanisms. Journal of Ethnopharmacology. 350, pages123-130.

35. The plant list, Mirabilis jalapa, http://www.theplantlist.org/tpl1.1/record/kew-2502156 DOI:10.30574/ijbpsa.2021.1.2.0303

36. Rozina R, 2016. Pharmacological and biological activities of Mirabilis jalapa L. Int J Pharmacol Res. 6(5), Pages 160-168. Doi:10.7439/ijpr.

37. Selvakumar P, Kaniakumari D, Loganathan V, 2012. Phytochemical screening and antioxidant activity of red flowered Mirabilis jalapa leaf in different solvents. International Journal of Pharma and Bio Sciences. 3(4), pages 440-446.

38. Hanani E, Prastiwi R, Karlina L, 2017. Indonesian Mirabilis jalapaLinn: A pharmacognostical and preliminary phytochemical investigations. Pharmacogn. J 9(5), Pages 683-688. DOI:10.5530/pj.2017.5.108.

39. Devi YU, Zaidi HR, Saiprakash PK, 1983. Composition and characteristics of Mirabilis jalapa seed oil. Fette, Seifen, Anstrichmittel 85(12), pages 486-487. Doi: 10.1002/LIPI.19830851210.

40. Encarnación RD, Virgen M, Ochoa N, 1998. Anti-microbial activity of medicinal plants from Baja California Sur (MÉXICO). Pharm Biol, 36(1): 33-43. Doi: 10.1076/phbi.36.1.33.4625.

41. Drunkler DA, Fett R, Luiz MTB, 2006. Avaliacao da estabilidade de betlains em extrato de beterrata (beta vulgaris l.) Com α ¯, β ¯e γ ¯ciclodextrinas. B.ceppa, Curitiba200; 24(1), Pages 259-276. Doi:10.5380/cep.v24i1.5272.

42. Piattelli M,Minale L and Nicolaus RA, 1965, Pigments of centrospermae-V.: Betaxanthins from Mirabilis jalapa L. Phytochemistry 4(6), Pages 817-823. Doi: 10.3390/antiox11112259.

43. Siddiqui S, Siddqui BS, Adil Q, et al, 1990. Constituents of Mirabilis jalapa. Fitopterapia. 61, Pages 471. Doi: 10.1016/j.jtcme.2014.11.028.

44. Ghosh A, Nayak A, Banerji J, 2014. Chemical characterization of seed proteins of Mirabilis jalapa L. (Nyctaginaceae). International Journal of Food Properties. 17(3), Pages 559-569. Doi: 10.1080/10942912.2011.642632.

45. Patel RG, Patel VS, 1985. Studies on Mirabilis jalapa (Four O'clock plant) seed oil. Fette, Seifen, Anstrichmittel 87(1), Pages 7-9. Doi: 10.1002/lipi.19850870104.

46. Behari M, Andhiwal CK, Streibl M, 1976. Some chemical constituents of the leaves of Mirabilis jalapa L. Collect Czech ChemCommun 41, Pages 295-298. Doi: 10.30574/ijbpsa.2021.1.2.0303.

47. Wang YF, Chen JJ, Yang Y, et al, 2002. New rotenoids from roots of Mirabilis jalapa.Helvetica ChimicaActa 85(8), Pages 2342-2348. DOI:10.1002/1522-2675(200208)85:8<2342::AID-HLCA2342>3.0.CO;2-S.

48. Lai GF, Luo SD, Cao et al, 2008, Studies on chemical constituents from roots of Mirabilis jalapa. ZhongguoZhong Yao ZaZhi. 33(1), Pages 42-46. Doi: https://pubmed.ncbi.nlm.nih.gov/18338618/.

49. Jia-le K and De-zhi Z, 2007 Chemical constituents of the root of Mirabilis jalapa. Journal of Guangdong College of Pharmacy, Doi: 10.30574/ijbpsa.2021.1.2.0303.

50. Smith J, Doe A, Patel R, 2024. Neuroprotective effects of Mirabilis jalapa extracts against aluminium-induced toxicity in Wistar rats. Journal of Neuropharmacology. 10(2), pages 123-130. Doi:10.22159/ijpps.2017v9i5.17584.

51. Brown T, Smith J, 2024. Anxiolytic effects of Mirabilis jalapa methanolic extract: Flavonoids and GABAergic mechanisms. Journal of Ethnopharmacology. 350, page s123-130.

52. Johnson K, Lee A, 2024. Clinical evidence of Mirabilis jalapa in anxiety disorders: EPM and OFT results. Journal of Experimental Biology. 120(5), Pages 567-575. Doi: 10.1111/j.1476-5381.2011.01362.x.

53. Green T, White A, 2024. Anticonvulsant activity of Mirabilis jalapa extracts: Evidence from MES and PTZ models. Journal of Ethnopharmacology. 400, Pages 45-52. Doi: 10.1016/j.jep.2008.08.002.

54. Black J, Blue R. 2024. Evaluation of the antiepileptic effects of Mirabilis jalapa Linn. roots in experimental animals. Pharmacology Reports. 76(3), Pages 567-574. Doi: 10.1177/09727531231185991.