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Review Article

A Mini Review on Botany, Phytochemistry, and Bioactivities of *Jatropha podagrica* Hook. (Euphorbiaceae)

Loi Huynh[1], Thanh Nhan T. Nguyen[2], Xuan Anh N. Nguyen[2], Anh Dao L. Tran[3], Lac Thuy H. Nguyen[3], Kim Thuong P. Van[2], Manh H. Tran[2,*]

[1]*Institute of Pharmaceutical Education and Research, Binh Duong University, Thu Dau Mot city, Binh Duong province, Vietnam.*
[2]*School of Medicine and Pharmacy, The University of Danang, Da nang city, Vietnam*
[3]*Faculty of Pharmacy, The University of Medicine and Pharmacy at Ho Chi Minh city, Ho Chi Minh city, Vietnam*

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ABSTRACT

Jatropha podagrica Hook., a member of the Euphorbiaceae family and known as "Dầu lai có củ" in Vietnamese, has a rich traditional use in treating constipation, skin infections, jaundice, and fever. The plant's chemical profile includes flavonoids, coumarins, phenolic acids, diterpenoids, peptides, and steroids. Numerous studies have highlighted the diverse biological effects of *Jatropha podagrica*, encompassing antibacterial and anticancer properties, antioxidant activity, insecticidal effects, muscle relaxation, and hypotensive activity. Despite its promising medicinal attributes, *Jatropha podagrica* remains underutilized, largely due to a lack of awareness. This review aims to offer an up-to-date and comprehensive exploration of the botany, phytochemistry, and bioactivities of *Jatropha podagrica*. To compile this information, searches were conducted on scientific databases such as Google Scholar, Elsevier, Springer and PubMed. In conclusion, *Jatropha podagrica*, with its diverse bioactive compounds, emerges as a valuable resource for addressing various health conditions.

***Keywords*:** *Jatropha podagrica* Hook., Euphorbiaceae, antioxidant, insecticidal, muscle relaxation, hypotensive activity

Introduction

Characteristics of the Euphorbiaceae Family

The plants in the Euphorbiaceae family vary widely.[1] They can be herbaceous, sometimes very small ("Cỏ sữa lá nhỏ", plant name in Vietnamese for *Euphorbia thymifolia*), small woody (*Phyllanthus*, *Sauropus*), large woody (*Hevea*, *Croton*), or climbing vines (*Cenesmon*). Some species, like *Euphorbia quantiquorum* and *E. meloformis*, appear similar to plants in the Cactaceae family but differ in having latex. Certain *Phyllanthus* species are epiphytic.[1,2] The leaves of Euphorbiaceae plants often have stipules. Leaves may be alternate, opposite, or whorled. They can be simple, entire, or with toothed or lobed margins, featuring pinnate or palmate venation. Some plants have compound leaves with pinnate or feather-like leaflets (e.g.,
Rubber Tree), while others have leaves resembling bird feathers (e.g., Castor oil plant, *Croton*). Some species may lack leaves but have thorns (Candelabra Tree), or they may have very small, early deciduous leaves without thorns (Skeleton plant). Leaf veins can be feather-like or palmate, and leaf stalks may sometimes bear glands.[2] The inflorescence is typically a cyme, raceme, or umbel. The Euphorbiaceae and Poinsettia genera exhibit a distinctive type of inflorescence called a cyathium. At first glance, a cyathium may resemble a bisexual flower with a cup-shaped concave receptacle, but it is, in fact, a flowering structure consisting of male flowers surrounding a central stalk, which supports a single pistillate flower in the middle.

*Corresponding author. E mail: tmhung@smp.udn.vn
Tel: +84972148084

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Each male flower of *J. podagrica* reduces to a single stamen. The cyathia cluster together to form complex inflorescences.[2,3]

The flowers of Euphorbiaceae plants often exhibit radial symmetry, either actinomorphic or zygomorphic, and commonly possess a nectar disc within the stamen whorl (for male flowers) or around the base of the ovary (for female flowers).[2] Floral parts may include 5 adnate sepals and 5 free petals (as in Jatropha), no petals (as in cassava) with 5 adnate sepals, but sometimes reduced to 4, 3, or 2 sepals, or they may lack true petals (as in *Euphorbia*, *Poinsettia*).[2,3]

The androecium of Euphorbiaceae plants may have 1 stamen (*Euphorbia*, *Poinsettia*), 5 stamens adnate in a whorl (*Phyllanthus*), 10 stamens adnate in two whorls (*Cassava*, *Jatropha*), numerous free stamens (Kamala), stamens branching with each branch terminating in a pollen sac (Castor oil plant), or a solitary stamen (Sandbox tree). The pollen sac membrane comes in various types: 3 grooves, grooved with holes, many holes, or without grooves.[4,5] The gynoecium may consist of 3 fused carpels forming a superior ovary with 3 locules, each locule containing 1 or 2 ovules. The styles may be free or fused, splitting once or twice. The locule opening is always covered by a cap, a thickened knob from the leading edge of the placental bundle, assisting in guiding pollen tubes to the locule opening. The cap differs from a stigma and disappears once the seed is mature. In some cases, the number of stigmas is fewer than 3 (2 in *Mercurialis*) or more than 3 (15–20 in sandbox tree).[2,3]

The fruit of Euphorbiaceae plants is a capsule that dehisces into 3 segments. When mature, the fruit opens as follows: first, the septifrage releases a central column, then the capsule wall splits into 3 parts, revealing the carpel leaflets.[2] Finally, the fruit ruptures along the midrib, forming 6 segments of the capsule wall. Fruits can be fleshy (strawberry tree) or woody (rattlesnake plant). Seeds may have an aril formed by the expansion of the seed coat around the micropyle, a straight embryo, and an endosperm containing oil. In Vietnam, there are over 75 genera with approximately 425 species.[2-5]

Jatropha genus

The genus *Jatropha* is a diverse and widespread group comprising 175 known species belonging to the Euphorbiaceae family. The botanical name "Jatropha" has its roots in the Greek words "Jatros," meaning physician, and "trophe," meaning nourishment, reflecting the historical medicinal uses of this plant.[2] The genus includes succulent plants, shrubs, and woody species, primarily distributed in tropical and subtropical regions of Asia, Latin America, and Africa.[5] In Vietnam, there are 5 species of *Jatropha*, mainly cultivated. The *Jatropha* with tuber is often cultivated for ornamental purposes in family gardens, temple courtyards, and used for medicinal purposes in the medicinal gardens of communal health stations and traditional medicine clinics.

Botany of Jatropha podagrica

Morphological characteristics

Scientific name is *Jatropha podagrica* Hook. The Vietnamese name is "Dầu lai có củ", "Vạn linh", "Sen núi", "Sen lục bình", "Ngô đồng", or "Dầu lai lá sen". The other names are Guatemala rhubarb, Gouty Stemmed Jatropha (English).[5,6] *J. podagrica* is a small plant, reaching a height of about 30-150 cm, sometimes more. The base of the stem swells like a tuber. Leaves are solitary, oval or egg-shaped, nearly round, with shallow lobes forming 5 lobes, and they are smooth. Leaf stalks are long, attached inside the leaf blade, veins spreading like a bird's foot, and the leaf sheath is divided into narrow lobes. The inflorescence grows in leaf axils, forming a cluster, red in color, with 5 sepals and 5 petals, approximately 7-8 mm tall. The fruit is a capsule with a diameter of 1.5 cm. The flowering season is typically from May to July.[5,6]

J. podagrica exhibits a distinctive gouty stem that suddenly thickens and swells at the base, forming a bottle shape with wide dichotomously branched structures. The bark peels and is greyish, while the branches are thick and glabrous. Leaves are large, arranged in clusters of 6–8, broadly ovate-reniform or orbicular–suborbicular, reaching 12–30 cm in diameter. They are broadly peltate, truncate to broadly rounded at the base, and palmately (shallow to deep) 3–5 lobed almost halfway, with broad lobes that are shortly acuminate, acute, or sub-obtuse. The underside is pale glaucous, with 5–9 main nerves and almost straight lateral veins. The petioles are 8–20 cm long, 3–4 mm thick, and glabrous, while the stipules are long, pectinate into small rigid glandular segments, often persisting.[5,6]

The inflorescences are axillary, forming corymbose cymes that are multi-forked. Peduncles are 16–18 cm long, 3–4 mm thick, and glabrous, with thick, dense branches crowded at the top. Bracts are ovate, obtuse, simple, wavy along margins, and strongly thickened-keeled on the midrib, approximately 1 mm long, and scarious. Flowers are grouped in 5 or 6, with male flowers surrounding generally a solitary female flower in a cluster.[5,6]

Male flowers have slender pedicels (1–1.5 mm), a cupular calyx (1–1.5 mm), red and glabrous, lobed for half the length with rounded lobes, and oblong-obovate or oblanceolate spathulate petals (5–6 × ca 2 mm) that are glabrous, bright red, or dark orange. The disc is urceolate, and stamens are 6–8, with filaments 2–3 mm long, connate at the base, and linear-oblong anthers (ca 2.5 mm long). Female flowers have pedicels (1–2 mm thick), a cupular calyx lobed almost to the base (ca 1 mm long), orange-red and glabrous, with ovate lobes that are obtuse. The petals are oblong-spathulate (6–7 mm long, ca 2 mm across), bright red, and the disc is urceolate, connate, and glandular. The ovary is glabrous, ovoid (ca 2 mm long), the style is ca 1 mm long, and the stigma is thick and bilobed (ca 1.5 cm long).[5,6] The fruits are oblong, truncate, or obtuse, 3-lobed, approximately 1.5 cm long and 1.2 cm across, yellow and glabrous, with seeds measuring around 1 cm in length.[5,6]

Jatropha with tuber is a type of plant that prefers light or can tolerate partial shade, exhibits high drought tolerance, and can thrive in various types of soil. This cultivated plant requires minimal care yet consistently produces fruits, especially when grown in sunny areas. The seeds of the tuberous Jatropha have a high germination rate. Moreover, the plant has the ability to regenerate with nutritional vigor from stem segments buried in the soil. The leaves and stems of the plant can be harvested throughout the year and are commonly used in their fresh form. The plant parts primarily utilized are the leaves and stem bark, known scientifically as Folium et Cortex Jatrophae.[6]

J. podagrica (Figure 1) is a plant of the genus *Jatropha* that is widely used as an ornamental and in folk medicines for the treatment and prevention of various diseases.[6] This plant has been widely used in traditional therapies to effectively treat skin infections, jaundice, and fever,[7,8] sexually transmitted diseases such as gonorrhea,[9] pain relief,[10] gout,[11]and paralysis.[12,13] In addition, African ethnic medicine uses the oil from its seeds as a natural remedy to cure rheumatism, itching and relieve constipation, and its leaves are used as a hemostatic agent. In Nigeria, indigenous people use this plant to treat hepatitis.[14] *J. podagrica* was recognized for its diverse biological activities, encompassing antitumor, antibacterial, molluscicidal, and insecticidal properties.[15] *J. podagrica* also exhibited antipyretic, diuretic, choleretic, and laxative effects,[16] and possessed various medicinal and insecticidal properties, including antibacterial, antitumor, and antifeeding activities.[7,8,17,18] Studies on the phytochemical constituents of this plant led to the isolation of fatty acids, coumarins, steroids, flavonoids,[9,11,19] and diterpenoids.[6,7,13,20,21-26]

Chemical components

The primary chemical components of *J. podagrica* species include diterpenoids, coumarin, aliphatic acid, ferulic acid ester, alkaloids, flavonoids, volatile oil compounds, and various other important compounds.

Diterpenoids

A total of 31 diterpenoids have been identified and isolated from *J. podagica* (Figure 2). Notably, japodagrin (1) and japodagrone (2) are two diterpene macrolides.[4,28] Japodagrin features a common lathyran ring system in the Euphorbiaceae family, distinguishing itself as the first compound with an epoxide bearing 3 substituents on C1 and C2, japodagrone, on the other hand, is composed of a jatrophane framework.[27,28] Other diterpenoids include 4*Z*-jatrogrosidentadion (3), 15-*Epi*-4*Z*-jatrogrossidentadion (4), 2-hydroxyisojatrogrossidion (5), 2-epihydroxyisojatrogrossidion (6), jatrophone (7), and 16-hydroxyphorbol (8), which were isolated from the roots.[4,29,30] Lathyrane diterpenoids, such as jatropodagin A (9), jatropodagin B (10), 2-epi-isojatrogrossidion (11), isojatrogrossidion (12), jatrointelon F (13), jatrointelon G (14), and jatrointelon B (15), were also identified. Stem extracts revealed 2-hydroxyisojatrogrossidion (16), 2-epi-hydroxyisojatrogrossidion (17), 15-*epi*-4*E*-jatrogrossidentadion (18), 4*E*-jatrogrossidentadion (19), 4*Z*-jatrogrossidion (20), jatrocurcasenon D (21), sikkimenoids A (22), and sikkimenoid B (23).[26,27,30] Jatrogricaine A (24), a rare diterpenoid, was isolated from the stem, featuring a carbon 5/6/6/4 ring system, this compound (24) represents the first compound of this class from the genus *Jatropha*.[29] Jatropodagrene (25), jatrodagricaine A (26) and three derivatives, as 8α,15,16-trihydroxy-labd-13*E*-ene (27), kayadiol (28), labda-8,13*E*-diene-3,15-diol (29) were isolated from leaves and japodagricanone A (30), japodagricanone B (31) were isolated from leaves and branches.[27]

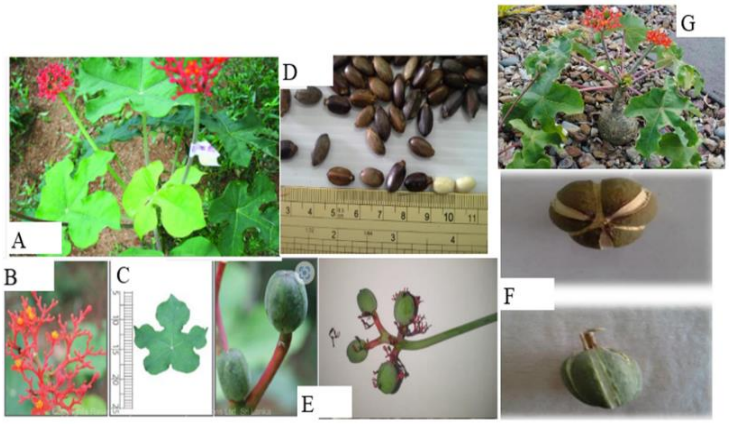

Figure 1: Pictures of *Jatropica podagrica*
(A) Young plant; (B) Fresh flowers; (C) Fresh leaves; (D) Seeds; (E) Fresh fruits; (F) Dried fruits; (G) Mature *J. podagrica* plant.

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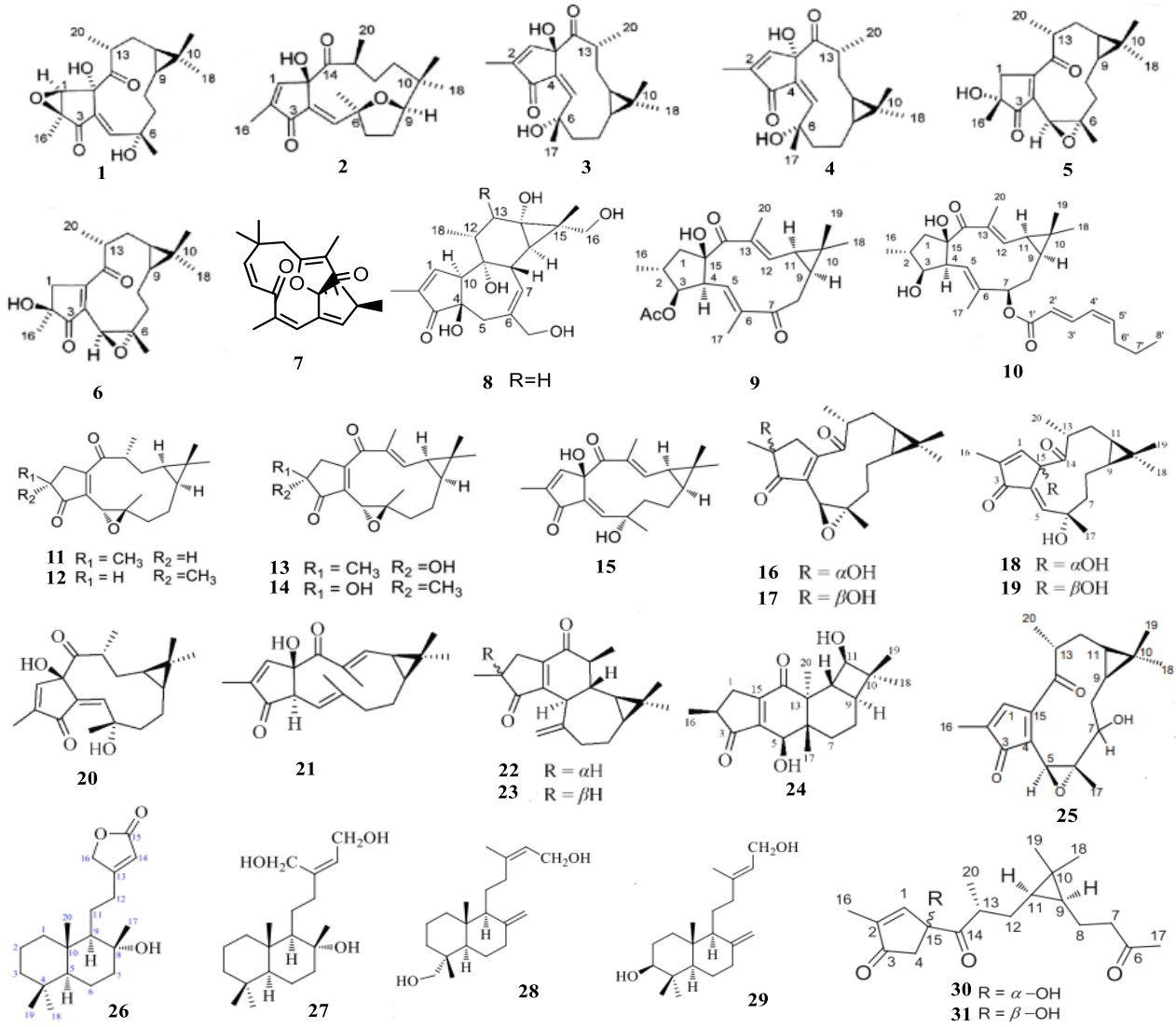

Figure 2: Diterpenoid compounds found in *J. podagrica*

Coumarins

From the bark of *J. podagrica*, three coumarin compounds (Figure 3) were isolated including fraxidin (32), fraxetin (33), and scoparone (34).[21]

Flavonoids

Numerous flavonoid compounds have been isolated from various parts of *J. podagrica*, predominantly from stems, seeds, and leaves (Figure 4). The identified flavonoids include apigenin (35), Acacetin (36), luteolin (37),[30] flavone-5-hydroxy (38), 7,4'-dimethoxyflavone (39),[3] vitexin (40), isovitexin (41), quercetin (42), and rutin (43).[21]

Fatty acids

The volatiles from both seeds and flowers of *J. podagrica* were analyzed using GCMS. In the seeds, eleven compounds were identified, constituting 84.3% of the total volatile components.[32] The predominant components in the seeds were palmitic acid (44, 40.8%) and linoleic acid (45, 16.6%). For the flowers, eleven compounds were identified, comprising 59.9% of the total volatile components. The key compounds in the flowers included palmitic acid (44, 17.8%), lauric acid (46, 13.8%), and phenol (10.4%).[32] (Figure 5).

Others

Several compounds, including 3-acetylaleuritolic acid (49), *β*-sitosterol (50), and sitosterone (51), were extracted from the bark of *J. podagrica*.[21] Additionally, noteworthy compounds such as japodic acid (52),[9] erythrinasinate (53), tetramethylpyrazine (54),[33] amide alkaloids with potential pharmacological activities isolated from plant roots, and cyclic peptides podacycline A (55) and podacycline B (56) from latex, along with ferulic acid ester[22] like *n*-heptyl ferulate (57), acetylaleuritolic acid (58), and tetradecyl-(*E*)-felurate,[28] were identified. Furthermore, γ-sitosterol, 6,7-dimethoxychromone (59) with antiallergic activity, was isolated from leaves (Figure 6).[34-36]

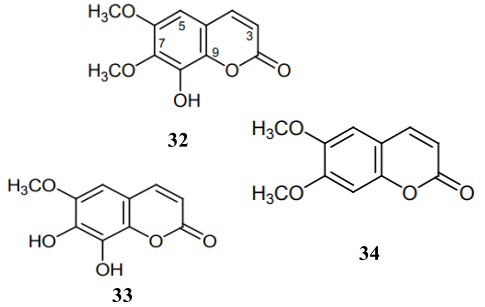

Figure 3: Coumarin compounds from *J. podagrica*

Pharmacological properties

Antibacterial and antioxidant activities

Two macrocyclic diterpenoids (1 and 2) demonstrated antibacterial activity against select gram-positive bacteria.[4] Japodagrin exhibited activity in standard disk assays against *Bacillus subtilis* (ATCC 6051) and *Staphylococcus aureus* (ATCC 25923), producing inhibitory zones of 16 and 12 mm, respectively, at a concentration of 20 µg/disk. Japodagrone (2) specifically showed activity against *B. subtilis* (ATCC 6051), with a zone of 12 mm at 20 µg/disk. Compounds 3–6, at the same concentration, displayed activity against *B. subtilis*, showing zones of inhibition at 20, 17, 31, and 35 mm, respectively, as well as *S. aureus* (10, 9, 21, and 26 mm, respectively). These compounds are likely contributors to the antibacterial activity observed in extracts of this plant. All the compounds were inactive in disk assays against *Escherichia coli* (ATCC 25922) and *Pseudomonas aeruginosa* (ATCC 27853).[4]

Hexane, chloroform, and methanol extracts of the rootwood and root barks of *J. podagrica* were evaluated for their antimicrobial activity against 18 organisms.[17] All extracts exhibited broad-spectrum antibacterial activity at a concentration of 20 mg/mL, with hexane extracts generally displaying higher activity than chloroform and methanol extracts. The hexane extract of the root bark demonstrated the highest activity among all extracts, comparable to gentamycin and superior in controlling *S. aureus* and *B. cereus*. Three extracts including hexane extract of the root bark, and hexane and methanol extracts of the rootwood showed moderate antifungal activity against the yeast fungus *Candida albicans*.[17] Two active ingredients, fraxidine and erythrinasinate, exhibited moderate activity with zones of inhibition measuring 12 mm and 15 mm, respectively against *S. aureus* (ATCC 29213), *B. subtilis* (ATCC 6051), *E. coli* (ATCC 25922), and *P. aeruginosa* (ATCC 27853).[9]

Insecticidal activity

Japodic acid, an aliphatic acid featuring a gem-dimethyl cyclopropane ring, was isolated from the roots of *J. podagrica*. It demonstrated mild insect growth inhibition activity against *Helicoverpa zea*, resulting in a 37% reduction in growth at 100 ppm.[4]

Immunomodulating activity

A natural cyclic peptide, podacycline B, was isolated from the latex of *J. podagrica*, renowned for its immunomodulating properties.[11]

Antitumor activities

Two novel lathyrane-type diterpenoids, jatropodagins A and B, isolated from *J. podagrica*, exhibited potent cytotoxicity. In particular, jatropodagins A displayed significant cytotoxic effects on two human osteosarcoma cell lines (MG-63 and Saos-2), with IC_{50} values of 8.08 and 14.64 µM, respectively, surpassing the positive control (5-FU). This finding strongly supports the potential development of jatropodagins A as a promising anticancer agent.[26]

Antifeedant activity

Hexane and methanol extracts of the root bark of *J. podagrica*, sourced from Nigeria, were evaluated for their antifeedant activity against third instar larvae of Chilo partellus. Both extracts demonstrated potent activity, with the hexane extract being the most effective, inducing 87.6% feeding deterrence at a dose of 100 µg/leaf disc.[8]

Anti-inflammatory activity

Jatrodagricaine A exhibited the ability to inhibit nitric oxide (NO) production in lipopolysaccharide (LPS)-induced RAW264.7 mouse macrophage cells, with an IC_{50} value of 40.6 ± 2.2 µM. Notably, this inhibitory effect was comparable to the positive control, minocycline (IC_{50} = 31.9 ± 1.7 µM). MTT testing revealed that jatrodagricaine A was not cytotoxic at high concentrations, specifically up to 150 µM.[29]

Antiviral activity

Jatropodagrene along with three known compounds have been isolated from the root bark of *J. podagrica* proved to be potential hepatitis C virus (HCV) inhibitors.[14]

Other activities

The neuromuscular and cardiovascular activities of tetramethylpyrazine, an amide alkaloid isolated from the stem of *J. podagrica*, were investigated *in vivo*.[33] The results indicated that the alkaloid extract exhibits neuromuscular blocking and hypotensive effects. Additionally, the extract demonstrated inhibition of electrically induced indirect contraction of the nictitating membrane in anesthetized cats.[33] Studies have revealed that tetramethylpyrazine has various potential pharmacological activities, including antibacterial effects,[36] anti-bronchospasm, and antiarrhythmic effects,[37] as well as anthelmintic activity.[38] The active ingredient 6,7-dimethoxychromone was also studied for its antiallergic activity.[34].

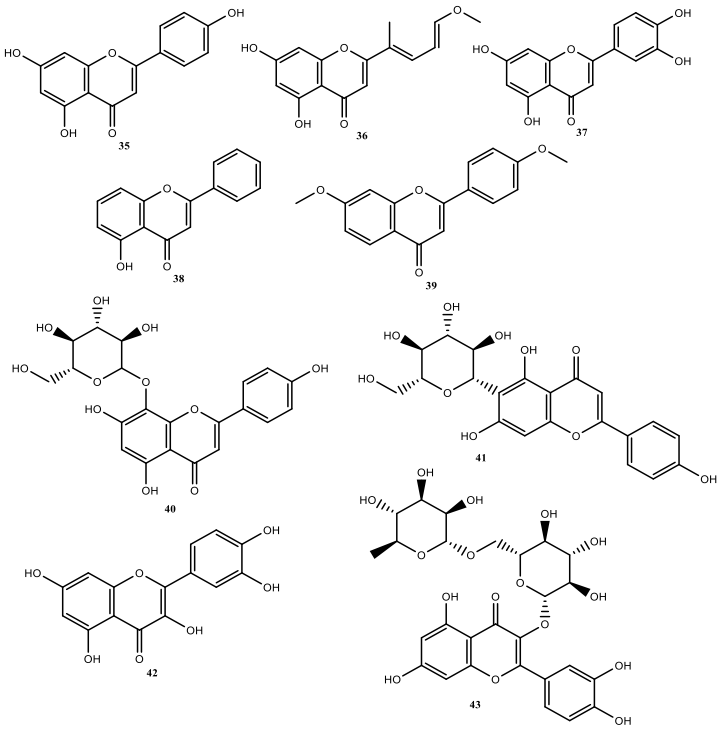

Figure 4: Flavonoid compounds found in *J. podagrica*

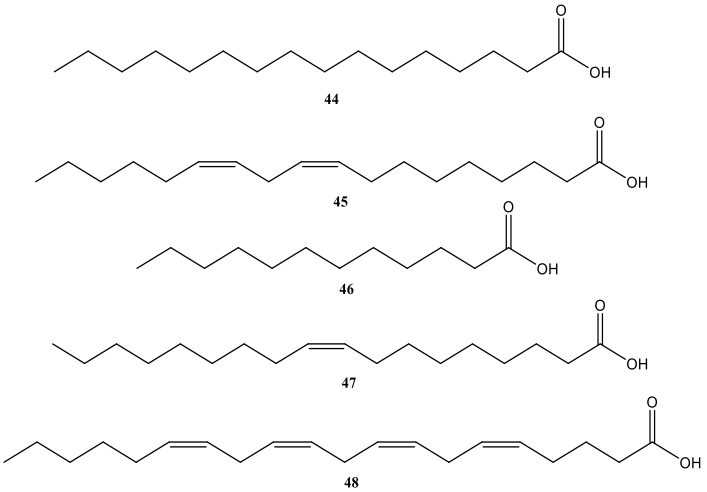

Figure 5: Fatty acid compounds found in *J. podagrica*

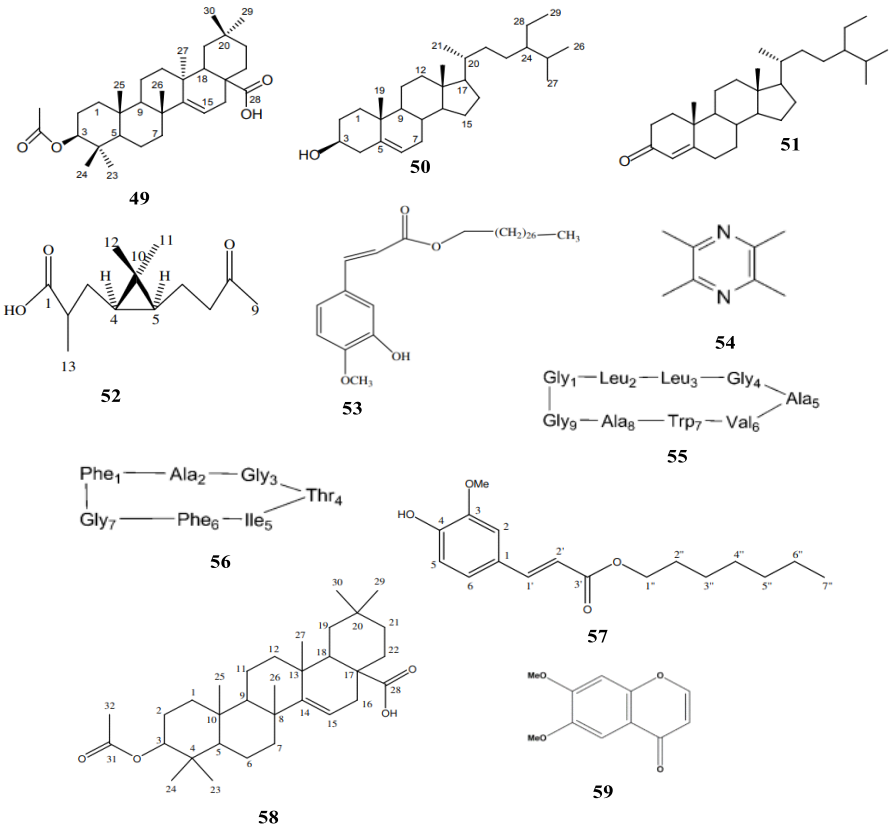

Figure 6: Other compounds found in *J. podagrica*

Conclusion

In summary, this review provides an overview of the botanical and chemical characteristics, as well as the principal pharmacological effects of *Jatropha podagrica*. Belonging to the genus Jatropha within the Euphorbiaceae family, *Jatropha podagrica* comprises various compounds, including diterpenoids, coumarins, flavonoids, and other bioactive substances. These compounds exhibit a diverse range of pharmacological properties, encompassing antibacterial, anti-inflammatory, antioxidant, insect growth inhibitory, anti-tumor, and antiviral activities. The findings presented in this review underscore the scientific basis for further exploration and research on *Jatropha podagrica*.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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