

Erythrina variegata Linn: A review on morphology, phytochemistry, and pharmacological aspects

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ABSTRACT

This review gives an account of the current knowledge on the morphology, phytochemistry, and pharmacological aspects of *Erythrina variegata*. *E. variegata* also called *Erythrina indica* is a thorny deciduous tree growing to 60 feet tall. A wide range of chemical compounds have been isolated, mainly alkaloids, flavonoids, triterpenoids, and lectin. Different parts of the plant have been used in traditional medicine as nervine sedative, collyrium in ophthalmia, antiasthmatic, antiepileptic, antiseptic, and as an astringent. The alkaloids extracted from the leaves of *E. variegata* are reported to have anti-inflammatory and analgesic activity. Isoflavonoids isolated from *E. variegata* having antibacterial and anthelmintic activity. *E. variegata* shows several other characteristic pharmacological effects like neuromuscular blocking, smooth muscle relaxant, CNS depressant, and hydrocholeretic, which are consistent with the reported uses of the plant extracts in the indigenous system of medicine. Hence the present article includes the detailed exploration of morphology, phytochemistry, and pharmacological aspects of *E. variegata* in an attempt to provide a direction for further research.

Key words: Alkaloids, antibacterial, cytotoxicity, *Erythrina variegata*, isoflavonoids

INTRODUCTION

The genus *Erythrina* comprises of about 110 species of trees and shrubs. The name “coral tree” is used as a collective term for these plants. Coral tree is indigenous to the Old World tropics, possibly originally from India to Malaysia, but is native of ancient westward to Zanzibar and eastward to eastern Polynesia (the Marquesas). It is typically found on sandy soil in littoral forest, and sometimes in coastal forest up to 250m (800ft) in elevation. The coral tree is cultivated particularly as an ornamental tree and as a shade and soil improvement tree (it fixes nitrogen) for other tree crops such as coffee and cacao. The most attractive type, var. *variegata*, is grown for its variegated leaves, as well as its seasonal showy red flowers.^[1-3] This fast-growing, 50-60 feet tall and wide deciduous tree with green and yellow-variegated, 6-inch-long leaves creates a broad canopy but has spiny branches. In spring, before the leaves appear, coral tree is decorated with showy red blossoms, each flower 2.5 inches long and arranged in dense, six-inch-long racemes. These blooms are followed by 12-inch-long, red/brown seedpods which contain poisonous seeds.^[4] Studies on phytochemical of *Erythrina variegata* species have demonstrated alkaloids and flavonoids as

major constituents.^[1] Different parts of *E. Variegata* have used in traditional medicine as nervine sedative, febrifuge, anti-asthmatic and antiepileptic.^[5] In the some experiments, it has potential effects for treatment of some diseases like convulsion, fever, inflammation, bacterial infection, insomnia, helminthiasis, cough, cuts and wounds.^[6-9]

TAXONOMY

Kingdom: Plantae – Plants
 Division: Magnoliophyta – Flowering plants
 Class: Magnoliopsida – Dicotyledons
 Family: Fabaceae (Legume family)
 Subfamily: Papilionoideae
 Genus: *Erythrina* L. – Coral Tree
 Species: *E. variegata* L.

Nonpreferred scientific names

Erythrina corallodendrum var. *orientalis* L.
Erythrina indica Lam.
Erythrina orientalis (L.) Merrill
Tetradapa javanorum Osbeck

Common names

Coral tree, Indian coral tree, tiger’s-claw (English)
 Gatae (Samoa, Horne Islands, ‘Uvea, Cook Islands)
 Dadap aykam (Java, Indonesia)

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MORPHOLOGY

Size

The tree grows up to 60 ft in height, but 33–48ft is more typical, with a spreading crown (except in the cultivar “Tropic Coral”). The dense, oblong to rounded crown is low-branching with many ascending branches.

Flowers

Inflorescence of many-flowered fascicles occurs in terminal or axillary racemes up to 20cm (8 in) or more long. Calyx is top-shaped, deeply split along one side, 1–1.8cm (0.4–0.7 in) long, on a pedicel 2–5mm (0.1–0.2 in) long. Corolla is papilionaceous; standard is short-clawed, ovate to subelliptic, 3–4cm (1.2–1.6 in) long, red-orange with longitudinal white lines; wings are about half as long as the standard, greenish to pale red; keel is as long as the wings, greenish to pale red. Ovary is superior, stamens 10, diadelphous, with 9 fused together at the base, enclosed within the keel. Flowering is reported from July to November in the southern hemisphere and 6 months later in the northern hemisphere.

Leaves

Leaves are trifoliolate, alternate; rachis is mostly 10–20 cm (4–8 in) long; blades are ovate to rhomboid, 8–18 cm (3.2–7.2 in) long; lateral ones are smaller than the terminal one, petioles 6–13 mm long, with vegetative parts finely pubescent. They are deciduous just before and during the flowering season, except for “tropic coral,” which has been reported by some authors to not drop its leaves, while other sources have noted its deciduous habit. *E. variegata* retains its leaves better than other *Erythrina* species in Hawai'i. Low temperatures, powdery mildew, and/or drought combined with very windy conditions will accelerate leaf drop and retard the development of new leaves.

Fruit

Fruit a compressed, narrowly oblong pod 10–14 cm (4–5.6 in) long, sterile in the basal portion, and not constricted between the 5–10 dark brown seeds. The fruits are ripe from October to November in the Southern Hemisphere and March to April in the Northern Hemisphere, but they often remain on the tree for several months longer.

Seeds

Seeds are kidney-shaped, dark purple to red, and 1–1.5 cm (0.4–0.6 in) in length. These simply fall to the ground and may be washed away (they have been seawater-dispersed over their native range). There are 1450–5000 seeds/kg (660–2270 seeds/lb).^[3,4]

PHYTOCONSTITUENTS

Alkaloids, flavonoids, pterocarpan, triterpenes, steroids, alkyl trans-ferulates, proteins, and lecithin [Figure 1] are found in the genus. Literature survey has revealed that a number of reports are available on *E. variegata*.

Alkaloids

The plant is a rich source of alkaloids (2.5%). (+)-3-Demethoxyerythratidinone, (+)-erythraline, (+)-erythramine, (+)-erythrinine, (+)-erythratidinone, (+)-erysonine, (+)-erysotone, (+)-erysodine, (+)-erysovine, (+)-11-hydroxy-*epi*-erythratidine, (+)-erythratidine, (+)-*epi*-erythratidine, (+)-erysodienone, (+)-erysotrine, (+)-erysopitine, (+)-11- β -hydroxyerysotrine[(+)-erythartine] are the tetracyclic alkaloids isolated from the various parts of plants^[7] and scoulerine, (+)coreximine, l-reticuline, and erybidine isolated from leaves.^[10] The ethanolic extract yielded chloroform-soluble and water-soluble bases, identified as erysovine and stachydrine.^[11] Eight spiroamine alkaloids along with three carboxylated indole-3-alkylmamines – hypaphorine, its methyl ester and *N*, *N*-dimethyltryptophan isolated from various parts of plant.^[8] Presences of isoquinoline (erythritol) and isococcolinine alkaloids are also reported in the studies.^[12]

Flavonoids

Flavonoids are chemical phenylbenzopyrones, which, usually conjugated with sugars, are present in all vascular plants.^[13] Isoflavonoids are reported to be the major phytoconstituents of *E. Variegata*. It contains mainly erythrinins A, B, and C, osajin and alpinum isoflavone, in addition to the styrene oxyresveratrol and dihydrostilbene dihydroxyresveratrol. Linear pyranisoflavones, robustone and 4-*O*-methylalpinum isoflavone are also isolated from the plant.^[14,15] The previous studies that reported erycricstagallin, orientanol B, erystagallin A,^[16] stigmaterol, campesterol,^[11] stigmoidins A, B, and C, phaseollin, 3- β -acetoxy-B-norcholest-5-ene, docosanoic methyl ester, 29-norcycloartenol, β -sitosterol and its archidate, and capric acid^[7] as main components refuted by recent well-documented and reliable investigations. Presence of flavonoid abyssinone V, erycricstagallin and 4-hydroxy-6, 3, 5-triprenylisoflavonone was confirmed in other studies.^[17] In recent studies two new diphenylpropan-1,2-diols, eryvarinols A and B, three new isoflavonoids, eryvarins M-O, two new 2-arylbenzofurans, eryvarins P and Q and a 3-aryl-2,3-dihydrobenzofuran, eryvarin R were isolated from the roots of *E. variegata* and their structures were elucidated on the basis of spectroscopic and chemical evidence.^[18,19] Bioassay-directed fractionation of the stem bark extract of *E. variegata* has resulted in the isolation of three new isoflavones: 5,4'-dihydroxy-8-(3,3-dimethylallyl)-2"-ethoxyisopropylfurano[4,5:6,7]isoflavone, 5,7,4'-trihydroxy-6-(3,3-dimethylallyloxiranylmethyl) isoflavone, 5,4'-dihydroxy-8-(3,3-dimethylallyl)-2"-hydroxymethyl-2"-methylpyranol [5,6:6,7] isoflavone and a new isoflavanone, 5,4'-dihydroxy-2'-methoxy-8-(3,3-dimethylallyl)-2"-2"-dimethylpyranol [5,6:6,7] isoflavanone, together with seven known compounds, euchrenone b₁₀, isoerysenegalensein E, wighteone, laburnetin, lupiwighteone, erythrodiol, and oleanolic acid.^[20] Other newly reported isoflavonoids of *E. Variegata* are epilupeol, 6-hydroxygenistein, and 3 β , 28-dihydroxyolean-12-ene.^[15]

Miscellaneous phytoconstituents

Various other constituents, which have been reported from *E. variegata* include erythrabysin II, dihydrofolinin,^[21] octacosyl

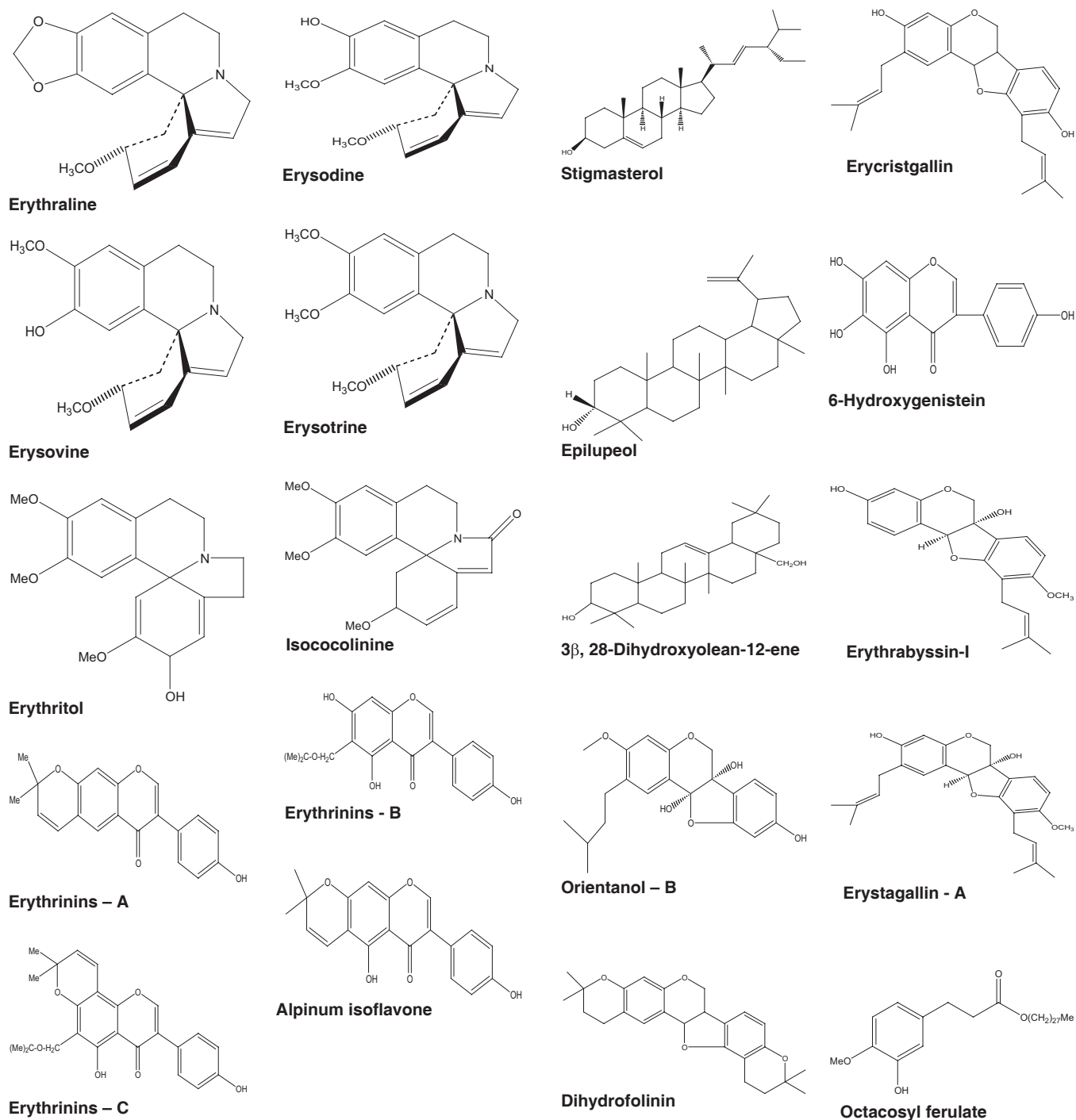


Figure 1 : Few isolated phytoconstituents of *E. variegata*

ferulate, wax alcohol, wax acids, alkyl ferulates, and alkyl phenolates.^[11] Seeds content moisture (3.8%), crude protein (31.2%), pentosan (11.9%), and water-soluble gum (1.6%). The amino acid composition of seed protein is as follows: alanine (7.2), arginine (3.4), aspartic acid (12.9), glutamic acid (13.4), glycine (7.6), histidine (3.9), isoleucine (3.6), leucine (7.1), lysine (5.1), methionine (0.5), phenylalanine (3.3), proline (4.7), serine (7.1), threonine (5.7), tyrosine (2.2), and valine (4.8) g/100g. The

seeds also contain isolecitins (EVL I, EVL II and EVL III), the kunitz-type trypsin inhibitors (ETIa and ETIb) chymotrypsin inhibitor (ECI).^[22]

PHARMACOLOGICAL ASPECTS

Indian coral tree in the South Pacific, in Pohnpei the leaves are reportedly used to make a drink to cure curses, and the smoke

from smoldering leaves, bark, or roots is inhaled for the same purpose. In Yap, the leaves and bark are reportedly used as a potion to treat stomachache. In Tonga the bark is mixed with others and used to treat stomachache. In Samoa, the leaves are occasionally used to treat eye ailments, and the bark is applied to swellings. In India, China, and Southeast Asia, the bark and leaves are used in many traditional medicines, including one said to destroy pathogenic parasites and relieve joint pain; the juice from the leaves is mixed with honey and ingested to treat tapeworm, roundworm, and threadworm in India; women take this juice to stimulate lactation and menstruation; it is commonly mixed with castor oil to treat dysentery; a warm poultice of the leaves is applied externally to relieve rheumatic joints; and the bark is used as a laxative, diuretic, and expectorant.^[23,24]

Antibacterial/dental caries prevention

Isoflavonoids isolated from *E. variegata* has been screened for antibacterial activity against methicillin-resistant *Staphylococcus aureus* and various other strains. Of the active compounds, erycristagallin and orientanol B showed the highest antibacterial activity. The antibacterial effect of erycristagallin to mutans streptococci was based on a bactericidal action. Erycristagallin (6.25µg/ml: MIC) completely inhibited incorporation of radio-labeled thymidine into *Streptococcus* mutans cells. Incorporation of radio-labeled glucose into bacterial cells was also strongly inhibited at MIC, and 1/2 MIC of the compound reduced the incorporation approximately by half. The findings indicate that erycristagallin has a potential as potent phytochemical agent for the prevention of dental caries by inhibiting the growth of cariogenic bacteria and by interfering with incorporation of glucose responsible for production of organic acids.^[15,16]

Antioxidant

The generation of free radicals and other reactive oxygen species in the body is compensated by an elaborate endogenous antioxidant system. However, due to many environmental, lifestyle, and pathological situations, excess radicals can accumulate, resulting in oxidative stress. The potential value of antioxidants in eradicating oxidative stress has provoked researchers to investigate for natural compounds with potent antioxidative activity but low cytotoxicity. Crude extract obtained from the *E. variegata* evaluated for their radical scavenging properties and assessed that it could be rich source of natural oxidants for applications.^[5]

Analgesic and anti-inflammatory

The alkaloids extracted from the leaves of *E. variegata* are reported to have anti-inflammatory activity. The leaves and barks are also used in fever and rheumatism.^[7] It has been reported that in acetic acid induced writhing model the methanolic extract of the leaf of *E. variegata* at a dose of 500 mg/kg showed significant antinociceptive activity with 49.03% inhibition of writhing response. The results were statistically significant ($P < 0.01$) in comparison to the control. In radiant heat tail-flick model, the extract also showed significant increase in the tail flick latency at a dose of 500mg/kg body weight with 36.02% elongation of tail flick time.^[9]

Cardiovascular effects

Despite improved pharmacotherapies and mechanical treatments, cardiovascular disease remains a principal cause of morbidity and mortality worldwide, with every chance that this burden will increase.^[25] The intravenous administration of the *E. variegata* seed extract at a dose, varying from 0.1 to 0.4 mg/kg produced a sharp and short-lived fall in BP, both in cats and rats in acute experiments. On the isolated frog hearts, the extract has no action in smaller dose but at a dose of 5 mg resulted a complete but reversible block of the heart.^[26]

CNS effects

In the study total alkaloid fraction from the bark showed several characteristic pharmacological effects: neuromuscular blocking, CNS depressant, and anticonvulsant effects which are consistent with the reported uses of the plant extracts in the indigenous system of medicine.^[8] *E. variegata* also causes passivity and decreases spontaneous activity with positive grip strength. This indicates CNS relaxant activity (anxiolytic) of this plant.^[5] The current therapeutic treatment of epilepsy with modern antiepileptic drugs (AEDs) is associated with side-effects, dose-related teratogenic effects, and approximately 30% of the patients continue to have seizures with current AEDs therapy. Natural products from folk remedies have contributed significantly in the discovery of modern drugs and can be an alternative source for the discovery of AEDs with novel structures and better safety and efficacy profiles. Evidence for anticonvulsant activity of *E. variegata* in the clonic seizure of pentylenetetrazole model has been tested in mice. As the protective effects of *E. variegata* in clonic seizure, it suggests that it could be useful for treatment of absence seizure.^[27]

Smooth muscle relaxant

Total alkaloidal fraction from bark caused smooth muscle relaxation of isolated rabbit ileum and inhibited spontaneous rhythmic contraction of isolated rat uterus in concentration of 0.5–2.0mg/mL. *E. variegata* behaves like a spasmolytic agent due to its relaxing activity; therefore, it can play an important role in conditions like diarrhea or spasm or colic pain.^[8]

Calcium homeostasis

E. variegata extracts were evaluated on calcium homeostasis in ovariectomized rats and the regulation on gene expression in duodenum and kidney. It improve the serum Ca level and inhibit the urinary Ca excretion in OVX rats, and this might be due to the upregulation of *E. variegata* on VDR mRNA expression in duodenum and CaBP-9k mRNA expression in kidney.^[28]

Antiosteoporotic effect

Study showed that *E. variegata* could suppress the high rate of bone turnover induced by estrogen deficiency, inhibit bone loss and improve the biomechanical properties of bone in the lab rats.^[29]

Trypsin/proteinase inhibitors

Study indicates that erythrina kunitz proteinase inhibitors

possess different potency toward serine proteinases in the blood coagulation and fibrinolytic systems, in spite of their high similarity in amino acid sequence.^[30]

Cytotoxicity

The lethality of the n-hexane, carbon tetrachloride, chloroform, and aqueous soluble fractions of the methanolic extract to brine shrimp was evaluated on *Artemia salina*. The LC50 were found to be 36.68, 4.67, 7.733, and 14.289 µg/mL for n-hexane, carbon tetrachloride, chloroform, and aqueous fractions, respectively. In comparison with the positive control (vincristine sulphate), the cytotoxicity exhibited by the carbon tetrachloride and chloroform-soluble fractions of the methanolic extract was significant. This clearly indicated the presence of potent bioactive principles in these extractives, which might be very useful as antiproliferative, antitumor, pesticidal, and other bioactive agents.^[15]

Cadmium removal

It has been reported that *E. variegata* leaf powder can be used as an effective adsorbent for the removal of cadmium, a priority pollutant from its aqueous solutions. The equilibrium agitation time for the cadmium biosorption onto *E. variegata* leaf powder is 50 min. The percentage removal increases with a decrease in the size of the adsorbent from 212 to 53µm. The percentage removal is increased with an increase in the adsorbent dosage from 10 to 50g/L. Percentage removal is increased significantly with increase in pH from 2 to 4. The percentage removal decreases as pH is increased beyond 7.^[31]

Zinc removal

Pollution is the addition of unwanted and undesirable foreign matter to environment as a result of enormous industrial development and modernization. The discharge of untreated solid, liquid, and gaseous wastes that contaminate the physiological and ecological environment is the greatest threat to mankind. Waste water contaminated with heavy metals is one of the most common environmental problems due to their toxicity. Zinc finds its way into water bodies through effluents from smelters, mining, processing plants, paints and pigments, pesticides, and galvanizing units. When zinc is present in the wastewater beyond the permissible limits of concentration, it becomes harmful to the living organisms. Successful metal biosorption has been reported by a variety of biological materials. Evidence for metal biosorption of *E. variegata* leaf powder has been reported in recent studies. It is observed that there is a significant increase in percentage removal of Zn(II) as pH increases from 2 to 3 and attains maximum when pH is 7. The agitation time is to be 60 min.^[32]

CONCLUSION

E. variegata has been ethnomedicinally used as a therapeutic agent for a variety of diseases, as we have illustrated in this article. Moreover, numerous research works have proven its uses beyond the ethnomedicinal ones in experimental animals. Alkaloids and flavonoids which were isolated from this plant may be responsible

for its pharmacological activities. The road ahead is to establish specific bioactive molecules, which might be responsible for these actions. Therefore the cultivation, collection, and further pharmacological exploration of *E. variegata* are essential.

ABBREVIATIONS USED

E. variegata, *Erythrina variegata*; MIC, minimum inhibitory concentration; AEDs, antiepileptic drugs; OVX, ovariectomized; VDR mRNA, vitamin D receptor mRNA; CaBP-9k, calcium binding protein; LC50, lethal concentration 50.

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