Erythrina variegata

Scientific Name

***Erythrina variegata* L.**

Synonyms

Chirocalyx candolleanus Walp., *Chirocalyx divaricatus* (DC.) Walp., *Chirocalyx indicus* (Lam.) Walp., *Chirocalyx pictus* (L.) Walp., *Corallodendron divaricatum* (Moc. & Sessé ex DC.) Kuntze, *Corallodendron orientale* (L.) Kuntze, *Corallodendron spathaceum* (DC.) Kuntze, *Erythrina alba* Cogniaux & Marchal, *Erythrina boninensis* Tuyama, *Erythrina carnea* Blanco nom. illeg., *Erythrina corallodendron* Linn., *Erythrina corallodendron* var. *orientalis* L., *Erythrina corallodendrum* Lour., *Erythrina divaricata* DC. nom. illeg., *Erythrina humeana* sensu R.Vig., *Erythrina indica* Lam., *Erythrina indica* var. *alba* W. S. Millard & E. Blatter, *Erythrina indica* var. *fastigiata* Guill., *Erythrina lithosperma* Blume ex Miq., *Erythrina lobulata* Miq. *Erythrina loureiri* G. Don, *Erythrina marmorata* Veitch ex Planch., *Erythrina mysorensis* Gamble, *Erythrina orientalis* (L.) Murr., *Erythrina parcellii* W. Bull, *Erythrina phlebocarpa* F.M. Bail., *Erythrina picta* L., *Erythrina rostrata* Ridl., *Erythrina spathacea* DC., *Erythrina variegata* f. *alba* Maheshw., *Erythrina variegata* f. *marmorata* Maheshw., *Erythrina variegata* f. *mysorensis* Maheshw., *Erythrina variegata* f. *orientalis* Maheshw., *Erythrina variegata* f. *parcellii* Maheshw., *Erythrina variegata* f. *picta* (L.) Maheshw., *Erythrina variegata* var. *orientalis* (L.) Merr., *Gelala alba* Rumphius, *Gelala litorea* Rumph., *Tetradapa javanorum* Osbeck

Family

Fabaceae, also placed in Papilionaceae

Common/English Names

Coral Tree, East Indian Coral Tree, East Indies Coral Tree, Indian Bean Tree, Indian Coral Bean, Indian Coral Tree, Lenten Tree, Mochi Wood Tree, Tiger's Claw

Vernacular Names

Bangladesh: Mandar
Burmese: Penglay-Kathit
Chinese: Hai Tong Pi, Hoi Tong Peh
Chuukese: Paar, Weeku
Cook Islands: Gatae
Fiji: Drala, Drala Dina, Rara, Rara Damu, Rarawai, Segar
French: Arbreau Corail, Arbre Corail À Feuilles Panachées, Arbre Corail De L'inde, Arbre Immortel, Bois Immortel, Bois Immortel Vrai, Pignon D'inde
German: Indischer Korallenbaum
Hawaiian: Wiliwili-Haole

T.K. Lim, *Edible Medicinal And Non-Medicinal Plants: Volume 7, Flowers*,
DOI 10.1007/978-94-007-7395-0_63, © Springer Science+Business Media Dordrecht 2014

India: Madaar, Modar, Ranga (Assamese), Deo, Deuya, Kanda Mathar, Maadaara, Madar, Mandaara, Palte Madar, Tepalte Madar (Bengali), Paanarvo (Gujerati), Dadap Pharhad, Dhobi-Palas, Jangli-Sem, Mahamed, Mandara, Palas, Pangara, Pangra, Panjira, Paribhadra, Parijat, Phārahaḍa, Raktamadar (Hindi), Bilee Vaarjipe, Bili Vaarjipae, Bilivarijapa, Haalivaana, Haaravaana, Haaru Vaana, Hongara, Hongarike, Kempu Vaari Jaapa, Kempuvarijapa, Mandaara, Mullu Murige, Mullumurunji, Murige, Muruku, Paarijaathaka, Pongaara, Vaarjipe Mara, Warjipe. (Kannada), Pongero (Konkani), Mandaram, Mullumurikku, Mulmurikk, Mulmurukku, Murikk, Murikku, Paribhadram, Penmurikk (Malayalam), Korou Angangba (Manipuri), Mandar, Paangaara, Pangara, Pangaru, Paringa, Phandra (Marathi), Fartuah (Mizo), Salotonoya (Oriya), Bahupushpah, Kantakipalasa, Mahamedah, Mandar, Mandara, Mandarak, Mandaravah, Mandaruh, Mazndatah, Paribhadra, Páribhadrah, Parijata, Pravalashmantakah, Raktapuspa, Sushpah, Sutikatah, Vyagulikesarah, Vidrumah (Sanskrit), Civappu-Moccai, Kaliyana, Kaliyana Murukku, Kaliyāṇa Murukkuvakai, Kaliyana Murunkai, Kannalamurukku, Kiñcukam, Muḷḷu-Murukku, Muṇmurukku Murukku, Murungu, Navir, Palacam, Paricatam, Savusayam, Veḷḷaikkavi (Tamil), Baadida Chettu, Baadidapu Chettu, Baadis Chettu, Baadisa, Baaditha, Baaditi, Baanditha Chettu, Baarjapu Chettu, Badida, Badidepuchettu, Baridamu, Mahaameda, Muchchekarra, Muchikatta, Paaribhadrakamu, Paaribhvyamu, Parijatamu, Rohinamu, Wngiram (Telugu)

Indonesia: Dadap Ayam, Dadap Laut (Javanese), Belendung, Dadap Belendung (Sundanese), Thethek (Madurese)

Japanese: Deigo, Deiko, Kaitohi

Khmer: Roluŏhs Ba:Y

Korean: Haedongp'i

Laotian: Do:K Kho, Th'o:Ng Ba:Nz

Malaysia: Dedap, Deap Batik, Cengkering

Marquesas: Natae, Netae

Nepalese: Mandar, Phalledo

Niue: Gate

Papua New Guinea: Ivini (Hula, Central Province), Ialawa (Wagawaga, Milne Bay), Balbal (Raval, East New Britain), Bubakai (Kokopo, East New Britain), Lehelehe (Lontis, Buka, North Solomons Province), Valval (Lamekot, New Ireland), Banban (Ugana, New Ireland)

Philippines: Andorogat, Dapdap, Kabrab (Bikol), Dapdap (Bisaya), Sabang (Bontok), Vuvak (Ibanag), Bagbag Dubdub (Ilokano), Dapdap, Sulbang (Pampangan), Dapdap, Karapdap, Kasindak (Tagalog)

Pohnpei: Paripein

Russian: Eritrina Indijskaia, Eritrina PëStraya, Eritrina Raznoobraznaia

Samoan: Gatae

Sri Lanka: Era Badu, Era Mudu, Katu Eramadu, Mandar, Murunga (Sinhalese)

Swedish: Indiskt Koralträd

Tahiti: 'Atae

Thailand: Thong Baan, Thong Phuek (Northern), Thong Laang Laai (Central), Thong Lang Dang (Bangkok)

Tibetan: Man D Ra Ba

Tongan: Ngatae

Vietnam: Hải Đồng Bì, Lá Vông, Thích Đồng Bì, Vông Nem

Yapese: Paar, Raar

Origin/Distribution

It is native to tropical Asia—from Taiwan and southern China through the Philippines, Indonesia, Malaysia, Thailand, Myanmar, India, islands in the Indian Ocean and all the way to tropical East Africa. Introduced and naturalized also in American and African tropical countries.

Agroecology

An adaptable species that grows in the humid tropics, subtropics and semiarid areas, occurring in zones with mean annual temperatures of 20–32 °C and mean annual rainfall of 800–

1,500 mm with 5–6 months of rainy periods. It occurs wild in deciduous forest from the coastal dunes and forests to an elevation of 1,500 m. It thrives best in full sun on a deep, well-drained, sandy loam, but they tolerate a wide range of soil conditions from sands to clays of pH 4.5–8.0. The tree is drought tolerant, fairly fire tolerant, and can tolerate brief periods of waterlogging.

Edible Plant Parts and Uses

Young and old leaves are eaten steamed or stewed as lalab with rice or mixed with other vegetables (Ochse and Bakhuizen van den Brink 1980). In Papua New Guinea, the leaves are eaten cooked (French 1986). The boiled flowers and young leaves are edible, cooked like string beans but in more water (Deane 2002–2012). Seeds are consumed after roasting or boiling but are poisonous when eaten raw (Burkill 1966). In Vietnam, the leaves of *E. variegata* are used to wrap 'nem' (a kind of fermented pork).

Botany

An erect much branched, medium-sized, deciduous tree up to 25 m high and a spread of 8–12 m. Stem smooth, greyish with large scattered conical prickles on the stem and branch. Leaves are alternate, trifoliate, 20–30 cm long, the terminal largest; leaflet-stalk glandular (Plates 1 and 2). Leaflets are triangular to broadly rhomboid-ovate, with acuminate tips and obtuse bases, shining green. Inflorescence in dense axillary and terminal racemes appearing before the leaves (Plates 1 and 3); rachis tomentose; bracts small; flowers bright red; calyx tubular, minutely 5-toothed; corolla long, standard broad, ovate-elliptical, shortly clawed and 7–9 cm long, wings and keel subequal; stamens 10, connate basally, exserted; ovary multi-ovuled, style glabrous, incurved (Plates 3 and 4). Pods are black, cylindrical, long up to 38 cm, dehiscent and constricted between the glossy, reddish brown reniform seeds. Each pod has 5–10 seeds.

Plate 1 Terminal inflorescence and leaves

Plate 2 Trifoliate leaves (Chung GF)

Plate 3 Terminal inflorescence (Chung GF)

Plate 4 Close view of flowers (Chung GF)

Nutritive/Medicinal Properties

Leaf Nutrients/Phytochemicals

Food nutrient value of fresh leaves per 100 g edible portion reported is moisture 78.1 g, energy 69 kcal, protein 5.0 g, fat 0.7 g, carbohydrate 10.6 g, fibre 3.0 g, ash 2.6 g, Ca 639.1 mg, Fe 4.1 mg and P 109 mg (National Institute of Nutrition-University of Central Florida Project 2001–2004).

Erythaline and erythratine were isolated (Folkers and Koniuszy 1940). Leaves were reported to have a total alkaloidal content of 0.11 % constituting alkaloids erysotrine, erysodine, erysovine, erythaline, erysopine, erysopitine, erysonine, erysodienone, orientaline, hypaphorine, hypaphorine methyl ester and also N,N-dimethyltryptophan (Ghosal et al. 1970, 1972). From the leaves were isolated two alkaloids (erysothrine and hypaphorine) (Nguyen et al. 1991); two tetrahydroprotoberberine alkaloids (scoulerine and (+)-coreximine); a benzyltetrahydroisoquinoline alkaloid (L-reticuline); a dibenz[d, f]azonine alkaloid (erybidine); *O*-methylerybidine and *N*-norreticuline (Ito et al. 1973); scoulerine and coreximine (Ito 1999); 10,11-dioxoerythratidine (Herlina et al. 2005); phytol (Herlina et al. 2006); isolate 11 characterized as a triterpene pentacyclic 3b-11a-28-trihydroxy-oleane-2-ene and isolate 17 as a mixture of β-sitosterol and stigmasterol (Herlina et al. 2008); pentacyclic triterpenoid (3,22,23-trihydroxy-oleane-12-ene); pentacyclic triterpenoid (3b,11a-28trihydroxy-oleane-12-ene); and 10,11-dioxoerythratidine (Supratman et al.2010). Kalachaveedu et al. (2011) extracted β-sitosterol (433 mg, 1.445 w/w), oleanolic acid (65 mg, 0.217 % w/w) and β-sitosterol glycoside (108 mg, 0.36 % w/w).

The leaf was found to contain a lectin with molecular weight of 58 kDa, made up of two subunit molecular weights of 30 and 33 kDa (Konozy et al. 2002). The leaf lectin was found to be a glycoprotein with a neutral sugar content of 9.5 %. The leaf lectin was rich in acidic as well as hydrophobic amino acids and totally lacked cysteine and methionine. The N-terminal amino acids were Val-Glu-Thr-IIe-Ser-Phe-Ser-Phe-Ser-Glu-Phe-Glu-Ala-Gly-Asn-Asp-X-Leu-Thr-Gln-Glu-Gly-Ala-Ala-Leu-.

Flower Phytochemicals

The alkaloid, erythratine, elucidated as 11-hydroxyerysotrine, was isolated from the flowers in Egypt (El-Olemy et al. 1978). The flowers were found to contain 7-methoxy 8-(15-OH pentadecyl)-coumarin; phaseollin; 29-norcycloartenol; 3-β-acetoxy- β-norcholest-5-ene; docosanoic and capric acid; flavonoid abyssinone; prenylated isoflavonoids stigmoidins A, B and C, besides isoquinoline alkaloids erythritol; and isoquinoline alkaloid isococcoline, isoflavones alpinumisoflavone, erythrinin A,B and C, osajin and erythrabasin I (Sharma and Chawla 1992; Chawla and Sharma 1993). Two isoquinoline alkaloids designated erythrosotidienone and erythromotidienone plus stigmasterol, cycloartenol and erysotramidine were isolated from the acetone flower extract (Sharma and Chawla 1998).

Seed Phytochemicals

Marañon and Santos (1932) found an alkaloid, a fatty oil, and a saponaceous glucoside from the seeds. The alkaloid isolated had the properties identical with those of hypaphorine. From seeds

erythraline and 'free' and 'liberated' erysovine were isolated (Singh and Chawla 1970). The fatty acid composition of the seed oil was also determined. A prenylated flavone glycoside 5,7,4′-trihydroxy-3′-methoxy-8-C-prenylflavone 7-*O*-β-D-glucopyranosyl-(1 → 3)-α-l-arabinopyranoside (**1**) was isolated from the seeds (Yadava and Reddy 1999). Nitrogen contents of *E. variegata* seeds and deoiled seeds showed good protein content; albumin, globulin, prolamine and glutelin were separated out by fractionation (Samanta and Laskar 2008). Fractionation of protein was done to separate albumin, globulin, prolamine and glutelin. The total protein isolates (TPI) and the fractions isolated contained 17 amino acids, most of which were essential.

A D-galactose-binding glycoprotein lectin was purified from the seeds (Datta and Basu 1981). A mitogenic D-galactosephilic lectin was isolated from seeds (Gilboa-Garber and Mizrahi 1981). Kunitz-type trypsin inhibitors, ETIa and ETIb, and chymotrypsin inhibitor ECI were isolated from the seeds (Kouzuma et al. 1992). The proteins ETIa and ETIb comprised 172 and 176 amino acid residues with molecular weight 19,242 and 19,783, respectively, and shared 112 identical amino acid residues, about 65 % identity. A chymotrypsin inhibitor (ECI) isolated from seeds was found to have 179 amino acid residues with a pyroglutamic acid as the N-terminal residue and has a calculated molecular weight of 19,791 (Kimura et al. 1993). About 60 % of the residues of ECI were identical to those of ETIa and ETIb and the reactive sites, Arg63, in ETIa and ETIb were changed to Leu64 in ECI. A Bowman-Birk family proteinase inhibitor (EBI) isolated from the seeds was found to consist of 61 amino acid residues, the shortest among the Bowman-Birk family inhibitors sequenced to date, and with a molecular weight of 6,689 (Kimura et al. 1994). EBI could be classified as a group II inhibitor, showing the best homology (67 %) to the Bowman-Birk proteinase inhibitor from soybeans. *Erythrina variegata* chymotrypsin inhibitor (ECI) and chymotrypsin molecules were found to undergo aggregation in the complex-forming buffer simultaneously with a binary complex consisting of one ECI and one chymotrypsin molecule in a soluble form (Kimura et al. 1997). ECI comprised two peptides; the N-terminal peptide, ECI-(1-107)-peptide, containing the primary reactive site retained a slight inhibitory activity, while the C-terminal peptide, ECI-(108-179)-peptide, exhibited no inhibitory activity. It was demonstrated that amino acid residues Gln62 (P3), Phe63 (P2), Leu64 (P1) and Phe67 (P3′) in the primary binding loop of *Erythrina variegata* chymotrypsin inhibitor (ECI), a member of the Kunitz inhibitor family, were involved in its strong inhibitory activity towards chymotrypsin (Iwanaga et al. 1998). It was further shown that the intramolecular interaction between the primary binding loop and the scaffold of ECI played an important role in the strong inhibitory activity towards chymotrypsin (Iwanaga et al. 1999).

The purified seed isolectins (EVLI, EVLII and EVLIII) isolated from *E. variegata*, were all specific for galactopyranosides and N-acetylgalactosamine, and their affinities for simple sugars were EVLIII greater than EVLII greater than EVLI (Yamasaki et al. 1992). EVLI and EVLIII were found to be homodimers made up of an A-subunit of molecular mass 36,000 and a B-subunit of molecular mass 33,000, whereas EVLII a heterodimer composed of the A- and B-subunits. They found that there was no structural difference of the sugar chains linked to the two subunits of *E. variegata* galactose-specific isolectins (Yamaguchi et al. 1993). This together with the results of amino acid sequence comparisons indicated that the difference in molecular mass of these two subunits resulted almost wholly from the difference in the number of oligosaccharides linked to them.

Stem/Bark/Wood Phytochemicals

The petroleum ether bark extract was found to compose of wax alcohols and wax acids, alkyl ferulates, alkyl phenolates, stigmasterol, sitosterol, campesterol and citrostadienol/24-methylenelophenol (Singh et al. 1975). The ethanol bark extract yielded chloroform-soluble and water-soluble bases, identified as erysovine

and stachydrine, respectively. From the bark were isolated isoflavones (erythrinins A,B, C, osajin; alpinumisoflavone; and oxyresveratrol and dihydrooxyresveratrol) (Deshpande et al. 1977), alkaloids (erysotine, erythratidine, *epi*-erythratidine and 11-hydroxy-*epi*-erythratidine) (Chawla et al. 1988), three flavonoid phospholipase A_2 (PLA_2) inhibitors(4′-hydroxy-3′,5′-diprenylisoflavonone (abyssinone V) and 3,9-dihydroxy-2,10-diprenyl-pterocarp-6a-ene(erycrystagallin)and4′-hydroxy-6,3′,5′-triprenylisoflavonone) (Hedge et al. 1997), erythrinin B (Kobayahsi et al. 1997), alpinumisoflavone and two prenylated isoflavones (erythrivarones A and B characterized as dihydroalpinumisoflavone and 4′-hydroxy-[6″,6″-dimethyldihydropyrano(2″,3″:5,6)]-[6‴,6‴-dimethyldihy dropyrano(2‴,3‴:7,8)] isoflavone, respectively) (Huang and Yen 1996; 1997) and warangalone (Huang and Tseng 1998). Isoflavonoids, eryvarin A and eryvarin B, were isolated from wood (Tanaka et al. 2000). Two isoflavone derivatives named indicanines D and E together with 11 known compounds including six isoflavones (genistein, wighteone, alpinumisoflavone, dimethylalpinumisoflavone, 8-prenyl erythrinin C and erysenegalensein E), one cinnamate (erythrinassinate B), two pentacyclic triterpenes (oleanolic acid and erythrodiol) and two phytosterols (stigmasterol and its 3-*O*-β-D-glucopyranoside) were isolated from the stem bark (Nkengfack et al. 2001). Huang and Chiang (2004) isolated the following constituents from the methanol stem bark extract: triterpenoids, namely, lup-20(29)-en-3-one; β-amyrin; olean-12-en-3β, 22β-diol; olean-12-en-3β, 28-diol; 22β, 24-dihvdroxvolean-12-en-3-one; oleanonic acid; oleanolic acid; and olean-12-en-3β, 22β, 24-triol along with warangalone and 6,8-diprenylkaempferol.

From the stem bark, three isoflavones (5,4′-dihydroxy-8-(3,3-dimethylallyl)-2″-methoxyisopropylfurano[4,5:6,7]isoflavone (1), 5,7,4′-trihydroxy-6-(3,3-dimethylallyloxiranylmethyl) isoflavone (2) and 5,4′-dihydroxy-8-(3,3-dimethylallyl)-2″-hydroxymethyl-2″-methyl-pyrano[5,6:6,7]isoflavone (3)) and a new isoflavanone, 5,4′-dihydroxy-2′-methoxy-8-(3,3-dimethylallyl)-2″,2″-dimethylpyrano[5,6:6,7] isoflavanone (4), together with seven known compounds, euchrenone b10 (5), isoerysenegalensein E (6), wighteone (7), laburnetin (8), lupiwighteone (9), erythrodiol (10) and oleanolic acid (11), were isolated (Li et al. 2006). Genistein derivatives mainly in the form of prenylgenistein from this extract, including 6-prenylgenistein, 8-prenylgenistein and 6, 8-diprenylgenistein, were isolated from the stem bark (Zhang et al. 2008). Warangalone 8(3,3-dimethyl-allyl)-4′-hydroxy-2‴,2‴-imethylpyran[6,7,b]isoflavon was isolated from the stem bark (Herlina et al. 2009). The following secondary metabolites were isolated from the stem bark: alpinum isoflavone,6-hydroxygenistein,3β,28-dihydroxyolean-12-ene, epilupeol (Rahman et al. 2007) and three isoflavones (scandenone, 4′,5,7-trihydroxy-8-prenylisoflavone and 4′,5,7-trihydroxy-8-methylisoflavone) (Rahman et al. 2010). Liu et al. (2012) isolated erysopine and erysovine from the stem bark.

Root Phytochemicals

The following compounds were isolated from the roots: warangalone (scandenone), 5,7,4′-trihydroxy-6,8-diprenylisoflavone, erycristagallin, erythrabys-sin-II, phaseollin, phaseollidin, isobavachin and a cinnamylphenol, eryvariestyrene (*E*-1-[2, 4-dihydroxy-5-(3-methylbut-2-enyl)]-2-phenylethylene) (Telikepalli et al. 1990); pterocarpans, dihydrofolinin and erythrabyssin II, and the alkyl ester of ferulic acid, octacosyl ferulate (Ahmad et al. 2002); orientanol B (9-hydroxy3-methoxy-2γ, γ, dimethylallylpterocarpan), erycristagallin (3,9-dihydroxy-2,10-di(γ,γ-dimethylallyl)-6α,11α-dehydropterocarpan), cristacarpin, sigmoidin K, 2-(γ,γ-dimethylallyl)- 6α-hydroxyphaseollidin, erystagallin A (3,6α-dihydroxy-9-methoxy-2,10-di(γ,γ-dimethylallyl) pterocarpan) (Sato et al. 2002); two diphenylpropan-1,2-diols, eryvarinols A (1) and B (2) and their structures were elucidated as 1-(4-hydroxy-2-methoxyphenyl)-2-(4-hydroxy-3, 5-dimethoxybenzoyloxy)-3-(4-hydroxyphenyl) propan-1-ol (1) and its 3″-prenyl derivative (2)

(Tanaka et al. 2002a); 3,9-dihydroxy-2,10-di(γ,γ-dimethylallyl)-6α,11α-dehydropterocarpan (erycristagallin) and 9-hydroxy-3-methoxy-2-γ,γ-dimethylallylpterocarpan (orientanol B) (Tanaka et al. 2002b); two 3-phenoxychromones, eryvarins F and G, and their structures were elucidated as 3-(2,4-dihydroxyphenoxy)-7-hydroxy-6,8-di(3,3-dimethylallyl)chromen-4-one and 3-(2,4-dihydroxyphenoxy)-8-(3,3-dimethylallyl)-2,2-dimethylpyrano[5,6:6,7] chromen-4-one, respectively (Tanaka et al. 2003); three isoflavonoids, eryvarins M–O, two 2-arylbenzofurans, eryvarins P and Q, and a 3-aryl-2,3-dihydrobenzofuran, eryvarin R (Tanaka et al. 2004); two isoflavonoids, eryvarins S and T, and a new 2-arylbenzofuran, eryvarin U (Tanaka et al. 2005); a biisoflavonoid, biseryvarin A, was isolated from the roots (Tanaka et al. 2010); and two isoflavonoids, eryvarins V and W, and a chromen-4-one derivative, eryvarin X (Tanaka et al. 2011).

A 3-phenylcoumarin, indicanine A, was isolated from the root bark together with, robustic acid, daidzein and 8-prenyldaidzein (Nkengfack et al. 2000). The structure of the new compound was characterized as 4-hydroxy-5-methoxy-3-(4′-methoxyphenyl)-2″-(1-methylethenyl)dihydrofurano[4″,5″:6,7]coumarin. In addition to two known compounds, 5,4′-di-*O*-methylalpinumisoflavone and cajanin, a new 3-phenylcoumarin metabolite, named indicanine B, and a new isoflavone derivative, named indicanine C, were isolated from the root bark (Waffo et al. 2000). The structures of the new compounds were characterized as 4-hydroxy-3-(4′-hydroxyphenyl)-5-methoxy-2″,2″-dimethylpyrano [5″,6″:6,7] coumarin and 4′-hydroxy-5-methoxy-2″,2″-dimethylpyrano [5″,6″:6,7] isoflavone, respectively.

Antioxidant Activity

The crude methanol stem bark extract, n-hexane, carbon tetrachloride and chloroform soluble fractions showed moderate DPPH antioxidant activity (IC_{50} = 484.4–82.35 μg/ml), while the purified compounds, 4′,5,7-trihydroxy-8-prenyl isoflavone alpinum isoflavone and 6-hydroxygenistein, exhibited high antioxidant activity, having IC_{50} of 6.42, 8.30 and 8.78 μg/ml, respectively (Rahman et al. 2010). At the same time the standard compound, tert-butyl-1-hydroxytoluene (BUT), demonstrated an IC_{50} of 5.88 μg/ml.

Studies showed that the aqueous and methanol leaf extracts exhibited significant DPPH radical scavenging activity with an IC_{50} value of 342.59 and 283.24 μg/ml, respectively (Sakat and Juvekar 2010). The aqueous and methanol extracts significantly scavenged nitric oxide radicals (IC_{50} = 250.12; 328.29 μg/ml, respectively). Lipid peroxidation induced by thiobarbituric acid reactive substances (TBARS) was inhibited by the aqueous extract with low IC_{50} value (97.29 μg/ml) as compared to methanol extract (IC_{50} = 283.74 μg/ml). Both the extracts exhibited similar quantities of total phenolics. Total flavonoids were found to be in higher quantities than total flavonols in aqueous extract as compared to methanol extract.

Antimicrobial Activity

Among the isoflavonoids isolated from *E. variegata*, 3,9-dihydroxy-2,10-di(γ,γ-dimethylallyl)-6α,11α-dehydropterocarpan (erycristagallin) showed the highest antibacterial activity against mutants Streptococci, other oral Streptococci, *Actinomyces* and *Lactobacillus* species with a minimum inhibitory concentration (MIC) range of 1.56–6.25 μg/ml, followed by 3,6a-dihydroxy-9-methoxy-2,10-di(γ,γ-dimethylallyl)pterocarpan (erystagallin A) and 9-hydroxy-3-methoxy-2-γ,γ-dimethylallylpterocarpan (orientanol B) (MIC range: 3.13–12.5 μg/ml) (Sato et al. 2002).

Fourteen out of 16 isoflavonoids isolated from the roots showed antibacterial activity in the concentration range (1.56–100 μg/ml); the MIC values varied significantly among them (Tanaka et al. 2002b). Of the active compounds, 3,9-dihydroxy-2,10-di(γ,γ-dimethylallyl)-6α,11α-dehydropterocarpan (erycristagallin) and 9-hydroxy-3-methoxy-2-γ,γ-dimethylallylpterocarpan (orientanol B) exhibited the highest activity against methicillin-resistant *Staphylococcus aureus* with MIC values of 3.13–6.25 μg/ml. The phytochemical 2′,4′-dihydroxy-8-γ,γ-dimethylallyl-2″,2″-dimethylpyrano[5″,6″:6,7]

isoflavanone (bidwillon B), isolated from *Erythrina variegata*, inhibited the growth of 12 methicillin-resistant *Staphylococcus aureus* (MRSA) strains at minimum inhibitory concentrations (MICs) of 3.13–6.25 mg/l, while MICs of mupirocin, an antibiotic, were 0.20–3.13 mg/l (Sato et al. 2004). The minimum bactericidal concentration (MBC) for bidwillon B and mupirocin against MRSA weas 6.25–25 mg/l (MBC_{90}: 12.5 mg/l) and 3.13–25 mg/l (MBC_{90}: 25 mg/l), respectively. When bidwillon B and mupirocin were combined, synergistic effects were observed for 11 strains of MRSA (fractional inhibitory concentration indices, 0.5–0.75). The MBCs of mupirocin in the presence of bidwillon B (3.13 mg/l) were reduced to 0.05–1.56 mg/l. The results suggested t bidwillon B and mupirocin to be potent phytotherapeutics, and/or their combination may be useful in the elimination of nasal and skin carriage of MRSA.

Eryvarin Q, a 2-arylbenzofuran, isolated from the roots, showed potent antibacterial activity against methicillin-resistant *Staphylococcus aureus* (Tanaka et al. 2004). The isoflavonoid eryvarin U, isolated from the roots, exhibited potent antibacterial activity against methicillin-resistant *Staphylococcus aureus* (MRSA) strains (Tanaka et al. 2005).

The crude methanol bark extract showed comparatively strong growth inhibition of *Bacillus subtilis, Escherichia coli* and *Aspergillus niger*, while n-hexane soluble fraction of the methanol extract showed poor activity against most of the test microorganisms (Rahman et al. 2007). The carbon tetrachloride fraction of the methanol extract showed moderate growth inhibition of *Bacillus cereus, B. subtilis, E. coli, Pseudomonas aeruginosa, Shigella dysenteriae* and *Vibrio mimicus*. The chloroform soluble fraction showed strong activity against *B. cereus*, *B. subtilis*, *E. coli*, *P. aeruginosa* and *A. niger*. The aqueous soluble fraction showed significant activity against Gram-positive bacteria, namely, *B. cereus*, *B. subtilis, Sarcina lutea* and the Gram-negative bacteria, *P. aeruginosa*. This fraction also showed strong activity against *A. niger* and *Saccharomyces cerevisiae* and moderate activity against *Candida albicans*.

The isoflavonoid eryvarin W, isolated from the roots, exhibited potent antibacterial activity against methicillin-resistant *Staphylococcus aureus* (MRSA) strains (Tanaka et al. 2011). A biisoflavonoid, biseryvarin A, isolated from the roots showed low activity against methicillin-resistant *Staphylococcus aureus* (MRSA) (Tanaka et al. 2010).

Antitumour Activity

The ethyl acetate and n-butanol fraction of the ethanol stem bark extract but not the aqueous fraction promoted proliferation of the rat osteogenic sarcoma (UMR106), osteoblast-like (OB-like) cells (Li et al. 2006). Eleven compounds isolated from the ethyl acetate fraction including 4 new isoflavones and 7 known compounds, euchrenone b_{10}, isoerysenegalensein E, wighteone, laburnetin, lupiwighteone, erythrodiol and oleanolic acid, also stimulated UMR106 cell proliferation at concentrations of 5×10^{-8} to $5 - 10^{-6}$ mol/L but did not promote proliferation at 5×10^{-5} mol/L.

Among the proteinase inhibitors of *E. variegata*, EBI, which belongs to the Bowman-Birk family of inhibitors, was cytotoxic in relatively differentiated cells such as Molt4 and Jurkat derived from acute T lymphoblastic leukaemia (T-ALL) cells specifically, but ETIa and ECI, which are classified into Kunitz family inhibitors, did not (Ohba et al. 1998). The succinylation of lysine residue(s) of EBI led to about 50 % loss of the trypsin inhibitory activity as compared with the authentic EBI. When Molt-4 cells were incubated with this derivative, no significant cytotoxicity was observed, suggesting that the proteinase inhibitory activity might be involved in the cytotoxicity in human tumour cell lines. Erythrina alkaloid derivative, 10,11-dioxoerythratidine from the leaves, showed anticancer activity against breast cancer cell line T47D in vitro used with IC_{50} 1.0 µg/ml (Herlina et al. 2005). The methanol leaf extract of *E. variegata* and its ethyl acetate fraction and two compounds from the fraction isolate 11 and 17 exhibited anticancer activity against breast cancer T47D cell line in vitro

(Herlina et al. 2008). The potency against breast cancer cells ranked in the order of isolate 17 > isolate 11 > ethyl acetate fraction > methanol extract. Isolate 11 was characterized as a triterpene pentacyclic 3b-11a-28-trihydroxy-oleane-2-ene and isolate 17 as a mixture of β-sitosterol and stigmasterol. Rahman et al. (2007) evaluated the lethality of the *n*-hexane, carbon tetrachloride, chloroform and aqueous soluble fractions of the methanol bark extract to brine shrimp on *Artemia salina.* The LC50 were found to be 36.68, 4.67, 7.733 and 14.289 µg/ml, respectively. The cytotoxicity exhibited by the carbon tetrachloride and chloroform soluble fractions was significant and comparable to the positive control (vincristine sulphate). The results suggested that these fractions may be useful as antiproliferative and antitumorous bioactive agents.

Erythrina variegata extract exhibited antitumour effect in-vivo using the Lewis lung cancer mice model (Zhang et al. 2009). It also exhibited in-vitro antitumour effect against liver cancer cells. The methanol stem bark extract of *Erythrina variegata* showed significant anticancer activity against breast cancer T47D cell lines in vitro using the sulforhodamine B (SRB) assay (Herlina et al. 2011). Its bioactive component erystagallin A showed potent anticancer activity against breast cancer T47D cell lines in vitro with IC_{50} 3.3 µg/ml. Xanthoxyletin isolated from *E. variegata* exhibited antiproliferative effects in-vitro against human gastric adenocarcinoma SGC-7901 cells (Rasul et al. 2011). Its inhibitory effects on cells were associated with the DNA damage, apoptosis through mitochondrial dysfunction and cell-cycle arrest at S phase in a dose-dependent manner. Xanthoxyletin also increased the production of reactive oxygen species in SGC-7901 cells.

Studies showed that treatment of Dalton's ascitic lymphoma-induced Swiss Albino mice with methanol root bark extract of *Erythrina variegata* significantly increased the life span and decreased cancer cell number and tumour weight (Baskar et al. 2010). The haematological parameters were also normalized by the extract in tumour-induced mice.

Antiinflammatory Activity

Total alkaloids extracted from the leaves were found to have antiinflammatory activity (Nguyen et al. 1992). Three isoflavones, abyssinone V (1), 4′-hydroxy-6,3′,5′-triprenylisoflavonone (2) and erycrystagallin (3), isolated from the bark, exhibited phospholipase A2 (PLA2) inhibition with IC_{50} values of 6, 10 and 3 µM for 1 – 3, respectively (Hedge et al. 1997). The methanol leaf extract was found to have antiinflammatory activity as observed by reduction of the paw oedema (Verma et al. 2005). It contained indole alkaloids. Studies revealed that ethanol leaf extract of *E. variegata* produced above 90 % protection of the HRBC membrane from lysis due to hyposaline at dose level of 1,600 µg/ml when compared to 100 % lysis induced in control (Balamurugan et al. 2010). The standard drug, diclofenac, produced 95.26 % protection at a concentration of 50 mg/100 ml. The prevention of hypotonicity-induced HRBC membrane lysis was taken as a measure of antiinflammatory activity.

Blood Clotting Activity

Studies indicated that *Erythrina variegata* Kunitz proteinase inhibitors possessed different potency towards serine proteinases in the blood coagulation and fibrinolytic systems, in spite of their high similarity in amino acid sequence (Nakagaki et al. 1996). ETIa and ETIb, two Kunitz family trypsin inhibitors, prolonged the activated partial thromboplastin time (APTT) and also the prothrombin time (PT) of human plasma, but the Kunitz family chymotrypsin inhibitor, ECI, and Bowman-Birk family inhibitor, EBI, from *E. variegata* hardly prolonged these times. Trypsin inhibitors ETIa and ETIb inhibited the amidolytic activity of factor Xa and ETIb but not ETIA-inhibited plasma kallikrein. Neither ETIa nor ETIb exhibited any inhibitory activity towards beta-factor XIIa and thrombin. Furthermore, trypsin inhibitors ETIa and ETIb inhibited plasmin, a serine proteinase in the fibrinolytic system, whereas ECI and EBI did not. Of the two *Erythrina variegata* trypsin inhibitors designated

ETIa and ETIb, ETIa was found to have the ability to inhibit tissue-type plasminogen activator (tPA), while ETIb did not (Kouzuma et al. 1997a). They found that Arg61 and Leu62 residues in ETIa were important in inhibiting tPA and also suggest that beside these two residues, the other amino acid(s) or other structural element may be involved in interaction of ETIa with tPA. They also found that site-specific mutation of Arg63 to Leu (aR63L) or Asp (aR63D) in ETIa resulted in abolition of the inhibitory activities towards both trypsin and tPA (Kouzuma et al. 1997b). The result suggested that Arg61 and Leu62 in ETIa, in addition to Arg63, may play an important role in the interaction with tPA.

Immunomodulatory Activity

A D-galactose-binding glycoprotein lectin agglutinating human erythrocytes was purified from the seeds (Datta and Basu 1981). The lectin possessed leucoagglutinating property. A mitogenic D-galactosephilic lectin isolated from seeds was found to be similar to the soybean lectin in being a glycoprotein of molecular weight around 110,000–120,000 and having D-galactosephilic activity (Gilboa-Garber and Mizrahi 1981). The lectin resembled soybean and *Pseudomonas aeruginosa* lectins, by binding to D-GALACTOSAMINE, N-acetyl-D-galactosamine, alpha-galactoside and beta-galactoside as well as to D-galactose. Like these lectins it absorbed onto either untreated or enzyme (papain or neuraminidase)-treated human red blood cells but exhibited a considerable mitogenic activity towards human lymphocytes (predominantly T cells) only after their treatment with neuraminidase. This lectin was different in regard to the intensity of their agglutinating activity towards erythrocytes obtained from different animals and human donors of diverse ABO blood groups. Li et al. (1990) found that the Gal beta 1-4GlcNAc beta 1-3(Gal beta 1-4GlcNAc beta 1-6)Gal sugar sequence, an I-antigen determinant, was essential for the high affinity binding of the oligosaccharides to the *Erythrina variegata* agglutinin (EVA). The binding affinity of *Erythrina corallodendron* (synonym of *E. variegata*) seed lectin was found to be in the order N-acetyllactosamine > N-acetyl-D-galactosamine > α-galactoside and β-galactoside > D-galactose (Sudakevitz et al. 1991). Its ABO(H) blood group specificity revealed the following order of activity: O(H)I > A2 I > O(H)i adult > A2BI > BI > O(H)i cord > A1I > A1i adult > Bi cord > A1BI > Ai cord > ABi cord > OhI. The *Erythrina indica* (synonym of *E. variegata*) lectin showed a lower differentiation between the agglutination of O(H) and Oh erythrocytes. Both Erythrina seed lectins exhibited H/HI blood group preference.

Erythrina leaf lectin (EiLL) agglutinated all human RBC types, with a slight preference for the O blood group (Konozy et al. 2002). The carbohydrate specificity of lectin was directed towards D-galactose and its derivatives with pronounced preference for lactose. EiLL had pH optima at pH 7.0; above and below this pH lectin lost sugar-binding capability rapidly.

Anti-osteoporotic Activity

Studies by Zhang et al. (2007b) demonstrated that *Erythrina variegata* stem bark extract could suppress the high rate of bone turnover induced by oestrogen deficiency, inhibit bone loss and improve the biomechanical properties of bone in the ovariectomized rats. Daily oral administration of the plant extract at 300 and 600 mg/kg for 14 weeks to rats prevented the ovariectomy-induced increase in the serum osteocalcin, alkaline phosphatase and urinary deoxypyridinoline (DPD) levels. Histomorphometric analysis of the proximal end of the tibia showed that the extract prevented the oestrogen deficiency-induced decrease in trabecular thickness and trabecular area, as well as restoring the increase in trabecular separation in a dose-dependent manner. Also, the extract improved the energy absorption and stiffness of the mid-shaft of the rat femur. In a follow-up study, they isolated genistein derivatives mainly in the form of prenylgenistein from this extract, including 6-prenylgenistein, 8-prenylgenistein and 6, 8-diprenylgenistein (Zhang et al. 2008). They found genistein did not promote cell growth but genistein derivatives

exerted stimulatory effects on osteogenesis in UMR 106 cells. Further animal studies indicated that the protective effects of *E. variegata* stem bark extract on bone properties in ovariectomized rats were likely to be mediated by its inhibitory actions on the process of bone resorption via the suppression of osteoclast differentiation and maturation (Zhang et al. 2010). The extract inhibited the upregulation of cathepsin K mRNA and the downregulation of osteoprotegrin mRNA in the tibia of ovariectomized rats.

Calcium Homeostasis Activity

Oral administration of *Erythrina variegata* extracts could improve the serum Ca level and inhibit urinary Ca excretion in ovariectomized rats and maintain Ca homeostasis, and this might be attributed to the upregulation of the extract on vitamin D receptor mRNA expression in the duodenum and CaBP-9k mRNA expression in the kidney (Zhang et al. 2007a).

β-Glucosidase Inhibitory Activity

In the β-glucosidase inhibitory bioassay, the crude methanol extract, n-hexane, carbon tetrachloride and chloroform soluble fractions of *E. variegata* stem bark revealed 34.75, 95.04, 91.49 and 55.32 %, inhibition, respectively (Rahman et al. 2010).

Hypotensive Activity

The aqueous seed extract elicited a sharp fall in blood pressure and at higher dose completely stopped the heart in guinea pigs (Chatterjee et al. 1981). It also produced a contraction of isolated guinea pig ileum. The fall in blood pressure and contraction of ileum were completely blocked by an antihistaminic agent—diphenhydramine. The extract did not show any CNS activity, since it neither affected the barbiturate-induced sleeping time nor protected the pentylenetetrazol-induced convulsions, although it depressed the respiration at higher doses but stimulate the same in smaller doses in guinea pigs.

Antimalarial Activity

Erythrina alkaloid derivative, 10,11-dioxoerythratidine from the leaves, showed antimalarial activity against both strains of *Plasmodium falciparum* in-vitro used with IC_{50} of 25.5 μg/ml against strain 3D7 and 3.3 μg/ml against K1(Herlina et al. 2005). The methanol leaf extract of *E. variegata* exhibited significant antimalarial activity in-vitro towards *Plasmodium falciparum* (Herlina et al. 2007). Its *n*-butanol fraction gave the most potent activity, exhibiting equipotency against both strains of the parasite with IC_{5O} of 5.1 μg/ml against K1 and 13.2 μg/ml/against 3D7. The methanol bark extract of *E. variegata* showed significant antimalarial activity towards *Plasmodium falciparum* in vitro using the lactate dehydrogenase (LDH) assay (Herlina et al. 2009). Its ethyl acetate fraction showed the highest activity, exhibiting equipotency against both strains of parasite with IC_{50} of 23.8 μg/ml against 3D7 and 9.3 μg/ml against K1. The active component of the fraction isolated was identified as warangalone, 8(3,3-dimethylallyl)-4′-hydroxy-2‴,2‴-imethylpyran[6,7,b]isoflavon which showed significant antimalarial activity against both strains with IC_{50} of 4.8 μg/ml against 3D7 and 3.7 μg/ml against K1. The methanol stem bark extract of *Erythrina variegata* showed significant antimalarial activity against *Plasmodium falciparum* in-vitro using the lactate dehydrogenase (LDH) assay (Herlina et al. 2011). Its bioactive component erystagallin A showed potent antimalarial activity against both strains of parasite in-vitro used with IC_{50} of 0.02 μg/mL against 3D7 and 6.0 μg/mL against K1, respectively. The pentacyclic triterpenoid, 3,22,23-trihydroxy-oleane-12-ene (1); pentacyclic triterpenoid, 3b,11a-28trihydroxy-oleane-12-ene (2); and 10,11-dioxoerythratidine (3) isolated from the ethyl acetate fraction of the methanol extract of dried leaves showed antimalarial activity (Supratman et al. 2010). Compound 3 showed antimalarial higher than compounds 1

and 2 against *P. falciparum* K1 strains resistant to chloroquine due to the presence of epoxy group in pyran ring.

Antihyperlipidaemic Activity

The elevated levels of total cholesterol, triglycerides, low-density lipoprotein and very low-density lipoprotein due to high-fat diet (HFD) was significantly reduced by concurrent treatment with methanol seed extract of *E. variegata* (200 and 400 mg/kg) (Balamurugan and Shantha 2010). A significant reduction in high-density lipoprotein was found in HFD-fed groups; however, a nonsignificant increment was produced by the administration of the extract. The extract reduced the elevated body weight and mesenteric fat pad weight and the enhanced HMG-CoA reductase activity of HFD hyperlipidaemic rats. The extract also significantly reduced antioxidant enzymes such as superoxide dismutase and catalase and lipid peroxidation in HFD rats. Administration of *E. variegata* leaf extract to guinea pigs fed on a high-fat diet reduced TC (33 %), triglyceride (TGL; 39 %) and LDL (36 %), while high-density lipoprotein (HDL) levels remained unaltered demonstrating its marginal hypolipidaemic influence (Kalachaveedu et al. 2011). Atherosclerotic changes in coronary histopathology caused by the high-fat diet were altered beneficially by the leaf extract.

Hypoglycaemic Activity

The methanol leaf extract of *E. variegata* exhibited promising hypoglycaemic action in streptozotocin (STZ)-induced diabetic rats substantiating its ethnomedicinal use (Kumar et al. 2011). The extract administered orally at doses of 300, 600 and 900 mg/kg significantly and dose-dependently reduced and normalized blood glucose levels as compared to that of STZ control rats, the 900 mg/kg dose being the most potent showing complete normalization of blood glucose levels. Serum biochemical parameters including lipid profile were significantly restored towards normal levels in the extract-treated rats as compared to STZ diabetic rats.

Antidiarrhoeal Activity

The ethanol leaf extract significantly modified normal defecation frequency as well as inhibited castor oil-induced diarrhoea in Wistar rats (Sonia et al. 2011). The extract also displayed a significant reduction in gastrointestinal motility in charcoal meal test. The findings suggested that the ethanol extract of leaves of *Erythrina indica* elicited potent antidiarrhoeal effects substantiating its traditional claim as an antidiarrhoeal agent.

Diuretic Activity

The ethanol, chloroform and ethyl acetate leaf extracts exhibited significant diuretic activity as evidenced by increased total urine volume and the urine concentration of Na^+, K^+ and Cl (Jesupillai et al. 2008). The results supported the use of the plant as a diuretic agent in traditional medicine.

Antifertility Activity

Phytol from *E. variegata* leaves exhibited antifertility effects on the spermatozoa of white rats (*Rattus norvegicus)* in-vitro at a concentration of 0.25×10^3 µg/µl (Herlina et al.).

Spasmloytic Activity

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 0.5–2.0 mg/ml (Ghosal et al. 1972). *E. variegata* behaved like a spasmolytic agent due to its relaxing activity, thus may have an important role in conditions like diarrhoea or spasm or colic pain. Erythrinin B from *E. variegata* bark significantly

inhibited the Na+/H+ exchange system of arterial smooth muscle cells, with minimum inhibitory concentrations of 1.25 μg (Kobayashi et al. 1997).

CNS (Central Nervous System) Activity

The total alkaloid fraction from the bark showed several characteristic pharmacological effects: neuromuscular blocking, smooth muscle relaxant, CNS depressant, hydrocholeretic and anticonvulsant effects, which were consistent with the reported uses of the plant extracts in the indigenous system of medicine (Ghosal et al. 1972). The ethanol, chloroform and ethyl acetate leaf extracts of leaves showed significant ($P<0.05$) anticonvulsant activity against maximal electroshock (MES) and pentylenetetrazol (PTZ)-induced convulsions in mice (Rajamanickam and Sathyanarayanan 2008). Ethanol extract gave more prominent activity when compared to other extracts.

The aqueous leaf extract showed potent sedative activity but no analgesic effects, as claimed by Sri Lankan Ayurvedic physicians (Ratnasooriya and Dharmasiri 1999). The methanol leaf extract showed mild sedative hypnotic activity when evaluated using pentobarbital (Verma et al. 2005). However, in a later study, the methanol leaf extract was found to have analgesic activity. In acetic acid-induced writhing model, the methanol leaf 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 (Haque et al. 2006). In radiant heat tail-flick model, the extract also showed significant increase in the tail-flick latency at a dose of 500 mg/kg body weight with 36.02 % elongation of tail-flick time. As the crude extract appeared to be active in both animal models of nociception, it may possess peripherally and centrally acting compounds for its antinociceptive action.

Marañon and Santos (1932) isolated an alkaloid from the seeds which had properties identical with those of hypaphorine. Hypaphorine had been found to promote sleep in mice (Ozawa et al. 2008).

Toxicity Activity

The leaves and bark were found to contain the toxic alkaloid, erythrinine, a central nervous system depressant with effects similar to the alkaloid cytosine (Greshoff 1890; Nellis 1997). Symptoms reported included vomiting, malaise, lethargy and depression (Nellis 1997). Erythrinine was also isolated from the plant by Ito et al. (1970).

Traditional Medicinal Uses

A wide range of chemical compounds have been isolated, mainly alkaloids, flavonoids, triterpenoids and lectin from *E. variegata*. In Asia and the Pacific Islands, different parts of the plant have been used in traditional medicine for a variety of ailments and as nervine sedative, collyrium in ophthalmia, antiasthmatic, antiepileptic, antiseptic, astringent, febrifuge, anti-bilious, diuretic, laxative, expectorant, anthelmintic, vermifuge and an astringent (Crevost and Petelot 1928; Burkill 1966; WHO 1998; Rahman et al. 2007, 2010; Stuart 2012; Kumar et al. 2010).

The bark is used as a laxative, diuretic, expectorant astringent, febrifuge, anti-bilious and anthelmintic and is useful in ophthalmia and skin diseases. The bark is also employed to facilitate the maturation of boils. Dried bark decoction or infusion in alcohol is used for lumbar and leg pain. The stem bark is used against rheumatism in the form of a decoction, extract or tincture and an infusion used for stomachache. The bark when crushed and pounded is used for curing toothache by inserting into cavities or hollow tooth. The bark is chewed for dysentery. A mixture of bark scrapings and lime is applied to reduce swellings. The inner bark is scraped and mixed with little water; the juice is squeezed and drunk to cure cough with sore throat. The wood is rasped in water and given for haematuria. The bark and leaves are used in 'paribhadra', an Indian preparation as a vermifuge, for treating filariasis, and to relieve joint pain. A decoction of the bark and leaves, sweetened, is considered a good expectorant. The leaves and bark were found to contain the toxic alkaloid, erythrinine, a central nervous

system depressant with effects similar to the alkaloid cytosine (Greshoff 1890; Nellis 1997).

The leaves are employed in fever, inflammation and joint pains and as laxative, diuretic and expectorant. Heated crushed wet leaves are rubbed over the head and body of a person with fever. The juice of the leaves is used in earache, toothache, constipation and cough, and consuming the leaves is held to stimulate lactation, appetite and menstruation. The extract from crushed leaf mixed with water is drunk to relieve cough. Crushed fresh leaves are used externally as a poultice in haemorrhoids and metroptosis. Powdered leaves are topically applied for wounds and ulcers, and a warm poultice is applied externally to relieve rheumatic joints. Leaves are reported to be sedative and are used for the relief of insomnia and anxiety and for treating asthma. Leaves are crushed with seawater and drunk daily to relieve stomachache. Honeyed leaf juice is used as vermifuge for tapeworm and roundworm infestations. Pulverized leaves in the form of snuff are used for infantile convulsion and ascariasis. Leaves mixed with castor oil are used as therapy for dysentery.

The roots and leaves are considered to be febrifuge. The root decoction is used as a gargle for loose and aching teeth and an infusion used for bronchitis. Seeds used internally and externally for cancer and externally for abscesses. Pounded seeds are used as poultice for snake bites and for abscesses and cancerous growths.

Other Uses

Erythrina variegata is a multipurpose tree and an important agroforestry species. The species is simultaneously used as leaf forage and medicinal plant (in Vietnam especially grown for official purposes). It has also proven valuable for fodder production and as sturdy windbreaks. It is a useful plant for soil enrichment as it fixes nitrogen, nodulating readily and prolifically in both acid and alkaline soils and is also a good source of organic matter for green manure. In Asia and other tropical countries, it is a common ornamental tree for landscape, avenue planting and fencing/hedging purposes. It is also used as live support tree for black pepper, betel leaf, jasmine, grapes and yams and as a shade tree for coffee and cocoa. The soft and white timber has been used for making packing cases, floats, picture frames and toys, and recently pulp for the paper industry.

Erythrina variegata has insecticidal activity. Two alkaloids isolated from the stem bark, identified as erysopine and erysovine, exhibited antifeedant activity against maize weevil *Sitophilus zeamais* adults with EC_{50} values of 108.5 and 89.7 ppm, respectively (Liu et al. 2012). The D-galactose binding lectin from *E. indica* seeds significantly reduced egg hatching, pupation and emergence of the melon fruit fly, *Bactrocera cucurbitae* (Singh et al. 2009). Treatment of the larvae with the lectin significantly suppressed the activity of hydrolase enzymes (acid and alkaline phosphatases), one oxidoreductase (catalase) and one group transfer enzyme (glutathione S-transferases), but the esterases increased significantly.

Studies showed that *E. variegata* leaf powder could remove metal pollutant from solution. One study showed *E. variegata* leaf powder could bioadsorb zinc from aqueous solution (Venkateswarlu et al. 2008). There was a significant increase in percentage removal of Zn as pH increased from 2 to 3 and attained maximum at pH 7. In a subsequent study they found that *E. variegata* leaf powder could remove cadmium from solution; a significant increase in percentage removal of cadmium was observed as pH increased from 2 to 4 (Kumar et al. 2009).

Comments

E. variegata is readily propagated from seeds and woody stem cuttings.

Selected References

Ahmad WY, Said IK, Soon SY, Takayama H, Kitajima M, Aimi N (2002) A pterocarpan from *Erythrina variegata*. J Biol Sci 2:542–544

Backer CA, van den Brink Bakhuizen JRC (1963) Flora of Java (Spermatophytes only), vol 1. Noordhoff, Groningen, 648 pp

Balamurugan G, Shantha A (2010) Effect of *Erythrina variegata* seed extract on hyperlipidemia elicited by high-fat diet in Wistar rats. J Pharm Bioallied Sci 2(4):350–355

Balamurugan G, Balakrishnan, Supriyasajja D, Selvarajan S (2010) In vitro anti-inflammatory action of *Erythrina variegata* (L.) leaves by HRBC membrane stabilization. Int J Drug Dev Res 2(3):669–672

Baskar B, Devi P, Kumar RM (2010) Anti-cancer activity of methanol extract of root bark of *Erythrina variegata* Linn. Int J Toxicol Pharm Res 2(2):74–76

Burkill IH (1966) A dictionary of the economic products of the Malay Peninsula. Revised reprint, 2 vols. Ministry of Agriculture and Co-operatives, Kuala Lumpur, Malaysia, vol 1 (A–H), pp 1–1240, vol 2 (I–Z), pp 1241–2444

Chatterjee GK, Burman TK, Nag CAK, Pal SP (1981) Preliminary pharmacological screening of *Erythrina variegata* var. *orientalis* (syn. *E. indica*) seed. Indian J Pharm 13(2):153–158

Chawla HM, Sharma SK (1993) Erythritol, a new isoquinoline alkaloid from *Erythrina variegata* flowers. Fitoterapia 64:15–17

Chawla AS, Krishnan TR, Jackson AH, Scalabrin DA (1988) Alkaloidal constituents of *Erythrina variegata* bark. Planta Med 54(6):526–528

Crevost C, Petelot A (1928) Catalogue des produits de L'Indochine. Plantes Med Bull Econ Indochine. Impr. d'Extrême-Orient, 322 pp

Datta TK, Basu PS (1981) Identification, isolation and some properties of lectin from the seeds of Indian coral tree [*Erythrina variegata* (Linn.) var. *orientalis* (Linn.) Merrill]. Biochem J 197(3):751–753

Deane G (2007–2012) Coral bean: humming bird fast food. http://www.eattheweeds.com/coral-bean-humming-bird-fast-food/

Deshpande VH, Pendse AD, Pendse R (1977) Erythrinins A, B and C, three new isoflavones from the bark of *Erythrina variegata*. Indian J Chem Sect B 15:205–207

El-Olemy MM, Ali AA, El-Mottaleb MA (1978) *Erythrina* alkaloids. I. The alkaloids of the flowers and seeds of *Erythrina variegata*. Lloydia 41:342–347

Folkers K, Koniuszy F (1940) *Erythrina* alkaloids. VII. Isolation and characterization of the new alkaloids, erythraline and erythratine. J Am Chem Soc 62(2):436–441

Foundation for Revitalisation of Local Health Traditions (2008) FRLHT database. http://envis.frlht.org

French BR (1986) Food plants of Papua New Guinea, a Compendium. Australia Pacific Science Foundation, 407 pp

Ghosal S, Ghosh DK, Dutta SK (1970) Occurrence of erysotrine and other alkaloids in *Erythrina variegata*. Phytochemistry 9:2397–2398

Ghosal S, Dutta SK, Bhattacharya J (1972) *Erythrina*-chemical and pharmacological evaluation II: alkaloids of *Erythrina variegata* Linn. J Pharm Sci 61:1274–1277

Gilboa-Garber N, Mizrahi L (1981) A new mitogenic D-galactosephilic lectin isolated from seeds of the coral-tree *Erythrina corallodendron*. Comparison with *Glycine max* (soybean) and *Pseudomonas aeruginosa* lectins. Can J Biochem 59(5):315–320

Greshoff M (1890) Mitteilungen aus dem chemisch-pharmakologisehen Laboratorium de Botanischen Gartens zu Buitenzorg (Java). ChemBer 23:3537

Haque R, Ali MS, Saha A, Allimuzzaman M (2006) Analgesic activity of methanolic extract of the leaf of *Erythrina variegata*. Dhaka Univ J Pharm Sci 5(1–2):77–9

Hedge VR, Dai P, Patel MG (1997) Phospholipase A2 inhibitors from an *Erythrina* species from Samoa. J Nat Prod 60(6):1537–1539

Hegde N (1993) Cultivation and uses of *Erythrina variegata* in Western India, pp 77–84. In: Westley SS, Powell MH (eds) *Erythrina* in the new and old worlds. Nitrogen fixing tree reports Special Issue, Bangkok, 370pp

Herlina T, Muis A, Supratman U, Subarnas A, Sutardjo S, Syafruddin, Hayashi H (2005) Bioactive compounds of *Erythrina variegata* (Leguminosae). J Math Nat Sci 3:21–26

Herlina T, Julaeha E, Supratman U, Subarnas A, Sutardjo S (2006) Phytol, the antifertility agent from the leaves of dadap ayam (*Erythrina variegata*). Bionatura 3:215–223

Herlina T, Supratman U, Subarnas A, Sutardjo S, Abdullah NR (2007) Antimalarial activity from the leaves of dadap ayam (*Erythrina variegata*). Jurnal Kedokteran Yarsi 15(2):87–92

Herlina T, Supratman U, Soedjanaatmadja UMS, Subarnas A, Sutardjo S, Chomel R, Muhamad R, Abdullah NR, Ismail Z, Hayashi H (2008) Biologically active natural compounds from *Erythrina* plants. Proceedings of the international seminar on chemistry, Jatinangor, 30–31 Oct 2008, pp 204–207

Herlina T, Supratman U, Soedjanaatmadja UMS, Subarnas A, Sutardjo S, Abdullah NR, Hayashi H (2009) Anti-malarial compound from the stem bark of *Erythrina variegata*. Indo J Chem 9(2):308–311

Herlina T, Nurlelasari, Kurnia D, Supratman U, Udin Z (2011) In vitro anticancer and antimalarial erystagallin-A from *Erythrina variegata* (L) stem bark. Med Plant 3(1):9–13

Huang KF, Chiang JY (2004) Constituents of the Stem Bark of *Erythrina variegata* Linn. Chin Pharm J 56(3–6):133–139

Huang KF, Tseng CF (1998) Constituents of Erythrina variegata (III). Chin Pharm J 50:123–128

Huang KF, Yen YF (1996) Three prenylated isoflavones from *Erythrina variegata*. J Chin Chem Soc (Taipei) 43:515–518

Huang KF, Yen YF (1997) Constituents of *Erythrina variegata* (II). Chin Pharm J 49:21–29

Ito K (1999) Studies on the alkaloids of *Erythrina* plants. Yakugaku Zasshi 119(5):340–356 (In Japanese)

Ito K, Furukawa H, Tanaka H (1970) Structure of erythrinine, a new alkaloid from *Erythrina indica* Lam. J Chem Soc D 17:1076–1077

Ito K, Furukawa H, Haruna M, Lu ST (1973) Studies on the *Erythrina* alkaloids. IV. Alkaloids of *Erythrina*

orientalis (L.) Murr. Yakugaku Zasshi 93(12):1671–1674 (In Japanese)

Iwanaga S, Yamasaki N, Kimura M (1998) Chymotrypsin inhibitor from *Erythrina variegata* seeds: involvement of amino acid residues within the primary binding loop in potent inhibitory activity toward chymotrypsin. J Biochem 124(3):663–669

Iwanaga S, Nagata R, Miyamoto A, Kouzuma Y, Yamasaki N, Kimura M (1999) Conformation of the primary binding loop folded through an intramolecular interaction contributes to the strong chymotrypsin inhibitory activity of the chymotrypsin inhibitor from *Erythrina variegata* seeds. J Biochem 126(1):162–167

Jesupillai M, Jasemine S, Palanivelu M (2008) Diuretic activity of leaves of *Erythrina indica* Lam. Int Green Pharm 2(4):218–219

Kalachaveedu M, Kuruvilla S, Balakrishna K (2011) Effect of *Erythrina variegata* on experimental atherosclerosis in guinea pigs. J Pharmacol Pharmacother 2(4):285–287

Kimura M, Kouzuma Y, Yamasaki N (1993) Amino acid sequence of chymotrypsin inhibitor ECI from the seeds of *Erythrina variegata* (Linn.) var. *orientalis*. Biosci Biotechnol Biochem 57(1):102–106

Kimura M, Kouzuma Y, Abe K, Yamasaki N (1994) On a Bowman-Birk family proteinase inhibitor from *Erythrina variegata* seeds. J Biochem 115(3):369–372

Kimura M, Harada N, Iwanaga S, Yamasaki N (1997) Analysis of the complex formed by *Erythrina variegata* chymotrypsin inhibitor with chymotrypsin and properties of the peptides prepared from the inhibitor by a limited proteolysis. Eur J Biochem 249(3):870–877

Kobayahsi M, Mahmud T, Yoshioka N, Shibuya H, Kitagawa I (1997) Indonesian medicinal plants. XXI. Inhibitors of Na+/H+ exchanger from the bark of *Erythrina variegata* and the roots of *Maclura cochinchinensis*. Chem Pharm Bull (Tokyo) 45(10):1615–1619

Konozy EH, Mulay R, Faca V, Ward RJ, Greene LJ, Roque-Barriera MC, Sabharwal S, Bhide SV (2002) Purification, some properties of a D-galactose-binding leaf lectin from *Erythrina indica* and further characterization of seed lectin. Biochimie 84(10):1035–1043

Kouzuma Y, Suetake M, Kimura M, Yamasaki N (1992) Isolation and primary structure of proteinase inhibitors from *Erythrina variegata* (Linn.) var. o*rientalis* seeds. Biosci Biotechnol Biochem 56(11):1819–1824

Kouzuma Y, Yamasaki N, Kimura M (1997a) Cloning, expression, and mutagenesis of trypsin inhibitor ETIb from *Erythrina variegata* seeds. Biosci Biotechnol Biochem 61(6):1041–1043

Kouzuma Y, Yamasaki N, Kimura M (1997b) The tissue-type plasminogen activator inhibitor ETIa from *Erythrina variegata*: structural basis for the inhibitory activity by cloning, expression, and mutagenesis of the cDNA encoding ETIa. J Biochem 121(3):456–463

Kumar PR, Rao MV, Babu NC, Kumar PV, Venkateswarlu P (2009) Utilization of *Erythrina variegata* orientalis leaf powder for the removal of cadmium. Indian J Chem Technol 16:308–316

Kumar A, Lingadurai S, Jain A, Barman NR (2010) *Erythrina variegata* Linn: a review on morphology, phytochemistry, and pharmacological aspects. Pharmacogn Rev 4(8):147–152

Kumar A, Lingadurai S, Shrivastava TP, Bhattacharya S, Haldar PK (2011) Hypoglycemic activity of *Erythrina variegata* leaf in streptozotocin-induced diabetic rats. Pharm Biol 49(6):577–582

Le VT, Nguyen GC (eds) (1999) Selected medicinal plants in Vietnam, vol 1. National Institute of Materia Medica Science and Technology Publishing House, Hanoi, 439 pp

Li H, Yamamoto K, Kawashima H, Osawa T (1990) Structural requirements for the binding of oligosaccharides to immobilized lectin of *Erythrina variegata* (Linn) var. *orientalis*. Glycoconj J 7(4):311–322

Li XL, Wang NL, Wong MS, Chen ASC, Yao XS (2006) Four new isoflavonoids from the stem bark of *Erythrina variegata*. Chem Pharm Bull (Tokyo) 54(4):570–573

Liu ZL, Chu SS, Jiang GH, Liu SL (2012) Antifeedants from Chinese medicinal herb, *Erythrina variegata* var. *orientalis*, against maize weevil *Sitophilus zeamais*. Nat Prod Commun 7(2):171–172

Maranon J, Santos JK (1932) Morphological and chemical studies on the seeds of *Erythrina variegata* var *orientalis* (Linnaeus) Merrill. Phil J Sci 48(4):563–580

Nakagaki T, Shibuya Y, Kouzuma Y, Yamasaki N, Kimura M (1996) Inhibitory potency of *Erythrina variegata* proteinase inhibitors toward serine proteinases in the blood coagulation and fibrinolytic systems. Biosci Biotechnol Biochem 60(8):1383–1385

National Institute of Nutrition-University of Central Florida Project (2001–2004) Nutritive value from NIN -UCF project (2001–2004) of the Deccan Development Society (DDS) analysis, UCF project

Nellis DW (1997) Poisonous plants and animals of Florida and the Caribbean. Pineapple Press, Sarasota, Florida 416 pp

Nguyen VT, Pham TK, Pho DT, Do CH (1991) The pharmacological action of total alkaloids extracted from *Erythrina orientalis* (L.) Murr. Tap Chi Duoc Hoc 6:13–17

Nguyen VT, Pham TK, Pho DT, Do CH (1992) The anti-inflammatory effect of the total alkaloids extracted from the leaves of *Erythrina orientalis* Murr. Tap Chi Duoc Hoc 1:25–27

Nkengfack AE, Waffo AK, Azebaze GA (2000) Indicanine A, a new 3-phenyl coumarin from root bark of *Erythrina indica*. J Nat Prod 63(6):855–856

Nkengfack AE, Azebaze AG, Waffo AK, Fomum ZT, Meyer M, van Heerden FR (2001) Cytotoxic isoflavones from *Erythrina indica*. Phytochemistry 58(7):1113–1120

Ochse JJ, van den Brink Bakhuizen RC (1980) Vegetables of the Dutch Indies, vol 3. Ascher & Co., Amsterdam, 1016 pp

Ohba H, Nishikawa M, Kimura M, Yamasaki N, Moriwaki S, Itoh K (1998) Cytotoxicity induced by *Erythrina variegata* serine proteinase inhibitors in tumor hematopoietic stem cell lines. Biosci Biotechnol Biochem 62(6):1166–1170

Ozawa M, Honda K, Nakai I, Kishida A, Ohsaki A (2008) Hypaphorine, an indole alkaloid from *Erythrina velutina*, induced sleep in normal mice. Bioorg Med Chem Lett 18(4):3992–3994

Rahman MZ, Sultana SJ, Faruquee CF, Ferdous F, Rahman MS, Islam MS, Rashid MA (2007) Phytochemical and biological investigations of *Erythrina variegata*. Saudi Pharm J 15(2):140–145

Rahman MZ, Rahman MS, Kaisar A, Hossain A, Rashid MA (2010) Bioactive isoflavones from *Erythrina variegata* L. Turk J Pharm Sci 7(1):21–28

Rajamanickam MJMPV, Sathyanarayanan S (2008) Anticonvulsant effect of *Erythrina indica* Lam. Pharmacology Online 3:744–747

Rasul A, Khan M, Yu B, Ma T, Yang H (2011) Xanthoxyletin, a coumarin induces S phase arrest and apoptosis in human gastric adenocarcinoma SGC-7901 cells. Asian Pac J Cancer Prev 12(5):1219–1223

Ratnasooriya WD, Dharmasiri MG (1999) Aqueous extract of Sri Lankan *Erythrina indica* leaves has sedative but not analgesic activity. Fitoterapia 70:311–313

Sakat SS, Juvekar AR (2010) Comparative study of *Erythrina indica* Lam. (Fabaceae) leaves extracts for antioxidant activity. J Young Pharm 2(1):63–67

Samanta TD, Laskar S (2008) Chemical investigation of *Erythrina variegata* Linn. seed proteins. Food Chem 114(1):212–216

Sato M, Tanaka H, Fujiwara S, Hirata M, Yamaguchi R, Etoh H, Tokuda C (2002) Antibacterial property of isoflavonoids isolated from *Erythrina variegata* against cariogenic oral bacteria. Phytomedicine 10(5):427–433

Sato M, Tanaka H, Yamaguchi R, Kato K, Etoh H (2004) Synergistic effects of mupirocin and an isoflavanone isolated from *Erythrina variegata* on growth and recovery of methicillin-resistant *Staphylococcus aureus*. Int J Antimicrob Agents 24(3):241–246

Sharma SK, Chawla HM (1992) Isococcolinine: a new isoquinoline alkaloid from *Erythrina variegata* flowers. Indian J Heterocyclic Chem 2:71–74

Sharma SK, Chawla HM (1998) Structure elucidation of erythrosotidienone and erythromotidienone-two new isoquinoline alkaloids from *Erythrina variegata* flowers. J Indian Chem Soc 75:833–837

Singh H, Chawla AS (1970) Investigation of *Erythrina* spp. IV. Study of the chemical constituents of seeds of Erythrina variegata var. orientalis. Planta Med 19(1):71–74

Singh H, Chawla AS, Jindal AK, Conner AH, Rowe JW (1975) Investigation of *Erythrina* spp. VII. Chemical constituents of Erythrina variegata var. orientalis bark. Lloydia 38(2):97–100

Singh K, Kaur M, Rup PJ, Singh J (2009) Effects of Indian coral tree, *Erythrina indica* lectin on eggs and larval development of melon fruit fly, *Bactrocera cucurbitae*. J Environ Biol 30(4):509–514

Sonia J, Latha PG, Gowsalya P, Anuja GI, Suja SR, Shine VJ, Shymal S, Shikha P, Krishnakumar NM, Sreejith G, Sini S, Sekharan S (2011) Antidiarrhoeal effects of ethanolic leaf extract of *Erythrina indica* L. in experimental animals. Med Plants 3(1):81–83

Stuart GU (2012) Philippine alternative medicine. Manual of some Philippine medicinal plants. http://www.stuartxchange.org/OtherHerbals.html

Sudakevitz D, Gilboa-Garber N, Levene C, Sela R, Bhattacharyya L (1991) Erythrina lectins detect the H/HI blood groups. Zentralbl Bakteriol 275(3):343–350

Supratman U, Herlina T, Julaeha E, Kurnia D, Mayanti T, Harneti D, Nurlelasari, Maharani R, Fujita T, Hayashi H (2010) Biologically active natural products from Indonesian medicinal plants. Jurusan Kimia 19:19

Tanaka H, Etoh H, Shimizu H, Makita T, Tateishi Y (2000) Two new isoflavonoids from *Erythrina variegata*. Planta Med 66:578–579

Tanaka H, Hirata M, Etoh H, Watanabe N, Ahmad M, Terada Y, Fukai T (2002a) Two diphenyl-1,2-diol syringates from the roots of *Erythrina variegata*. J Nat Prod 65:1933–1935

Tanaka H, Sato M, Fujiwara S, Hirata M, Etoh H, Takeuchi H (2002b) Antibacterial activity of isoflavonoids isolated from *Erythrina variegata* against methicillin-resistant *Staphylococcus aureus*. Lett Appl Microbiol 35(6):494–498

Tanaka H, Hirata M, Etoh H, Shimizu H, Sako M, Murata J, Murata H, Darneidi D, Fukai T (2003) Eryvarins F and G, two phenoxychromones from the roots of *Erythrina variegata*. Phytochemistry 62(8):1243–1246

Tanaka H, Hirata M, Etoh H, Sako M, Sato M, Murata J, Murata H, Darnaedi D, Fukai T (2004) Six new constituents from the roots of *Erythrina variegata*. Chem Biodivers 1(7):1101–1108

Tanaka H, Sudo M, Hirata M, Sako M, Sato M, Chen IS, Fukai T (2005) Two new isoflavonoids and a new 2-arylbenzofuran from the roots of *Erythrina variegata*. Heterocycles 65(4):871–877

Tanaka H, Sudo M, Hirata M, Etoh H, Sato M, Yamaguchi R, Sakai E, Chen IS, Fukai T (2010) A new biisoflavonoid from the roots of *Erythrina variegata*. Nat Prod Commun 5(11):1781–1784

Tanaka H, Atsumi I, Shirota O, Sekita S, Sakai E, Sato M, Murata J, Murata H, Darnaedi D, Chen IS (2011) Three new constituents from the roots of *Erythrina variegata* and their antibacterial activity against methicillin-resistant *Staphylococcus aureus*. Chem Biodivers 8(3):476–482

Telikepalli H, Gollapudi SR, Keshavarz-Shokri A, Velazquez L, Sandmann RA, Veliz EA, Rao KVJ, Madhavi AS, Mitscher LA (1990) Isoflavonoids and a cinnamyl phenol from root extracts of *Erythrina variegata*. Phytochemistry 29(6):2005–2007

The Plant List (2012) http://www.theplantlist.org/

Tropicos Org (2012) Missouri Botanical Garden. http://www.tropicos.org

Venkateswarlu P, Durga GV, Babu NC, Rao MV (2008) Biosorption of Zn(II) from an aqueous solution by *Erythrina variegata* orientalis leaf powder. Int J Phys Sci 3:197–204

Verma SM, Amrisha, Prakash J, Sah VK (2005) Phytopharmacognostical investigation and evaluation of anti-inflammatory and sedative hypnotic activity of the leaves of *Erythrina indica* Lam. Anc Sci Life 25(2):79–83

Waffo AK, Azebaze GA, Nkengfack AE, Fomum ZT, Meyer M, Bodo B, van Heerden FR (2000) Indicanines B and C, two isoflavonoid derivatives from the root bark of *Erythrina indica*. Phytochemistry 53(8):981–985

Whistler WA, Elevitch CR (2006) *Erythrina variegata* (coral tree), ver. 3.1. In: Elevitch CR (ed) Species profiles for pacific island agroforestry. Permanent Agricultural Resources (PAR), Holualoa, Hawaii. http://www.tradi-tionaltree.org/

World Health Organisation (WHO) (1998) Medicinal plants in the South Pacific. WHO Regional Publications Western Pacific series no 19, 151 pp

Yadava RN, Reddy KI (1999) A novel prenylated flavones glycoside from the seeds of *Erythrina indica*. Fitoterapia 70(4):357–360

Yamaguchi O, Kimura M, Araki M, Yamasaki N, Kimura Y, Nakajima S, Takagi S (1993) Chemical structures of two subunits, A-subunit and B-subunit, of galactose-specific isolectins from *Erythrina variegata* seeds. J Biochem 114(4):560–566

Yamasaki N, Kimura M, Yamaguchi O, Araki M (1992) Isolation and characterization of isolectins from *Erythrina variegata* seeds. J Chromatogr 597(1–2):207–211

Zhang Y, Li XL, Huang WX (2007a) Effect of *Erythrina variegata* on Ca2+ homeostasis in ovariectomized rats and action mechanism. Zhongguo Zhong Yao Za Zhi 32(7):627–630 (In Chinese)

Zhang Y, Li XL, Lai WP, Chen B, Chow HK, Wu CF, Wang NL, Yao XS, Wong MS (2007b) Anti-osteoporotic effect of *Erythrina variegata* L. in ovariectomized rats. J Ethnopharmacol 109(1):165–169

Zhang Y, Li XL, Yao XS, Wong MS (2008) Osteogenic activities of genistein derivatives were influenced by the presence of prenyl group at ring A. Arch Pharm Res 31(12):1534–1539

Zhang H, Xiang JF, Tan L, Dai W, Bai G, Liu Y, Cao XL, Tang YL (2009) Anti-tumor activity of *Erythrina variegata* L. extract and its mechanism of action. Yao Xue Xue Bao 44(12):1359–1363 (In Chinese)

Zhang Y, Li Q, Li X, Wan HY, Wong MS (2010) *Erythrina variegata* extract exerts osteoprotective effects by suppression of the process of bone resorption. Br J Nutr 104(7):965–971