Bangladesh Pharmaceutical Journal ***19****(2): 237-253, 2016* **- Review paper**

Constituents of *Erythrina* - a Potential Source of Secondary Metabolities: A Review

Mohammad Musarraf Hussain[1], Md. Tariqul Haque Tuhin[2], Fahima Akter[3] and Mohammad A. Rashid[3]

[1]Department of Pharmacy, Jagannath University, Dhaka-1100, Bangladesh
[2]Department of Pharmacy, State University of Bangladesh, Dhaka-1205, Bangladesh
[3]Department of Pharmaceutical Chemistry, University of Dhaka, Dhaka-1000, Bangladesh

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Abstract

The genus *Erythrina* is a potential source of chemical constituents, many of which medicinal properties. Although some reviews on chemical constituents of particular *Erythrina* species could be found, no detailed review covering the chemistry of different *Erythrina* species has been reported to the best of my knowledge. Therefore, the aim of this review was to compile the phytoconstituents reported from various species of *Erythrina*. A total of 155 secondary metabolites have been published from 15 species of *Erythrina*. Among them *E. subumbrans* and *E. variegata* consist of the highest number of chemical constituents.

Key words: *Erythrina,* Phytoconstituents, Alkaloids, Flavonoids, Pterocarpans, Steroids, Triterpenes

Introduction

The genus *Erythrina* (Leguminosae) consists of 110 species of trees and shrubs. Among them, 15 different species have been thoroughly analyzed in this review. *E. addisoniae* is a wild tree, small to medium sized and contains good quantity of potassium salts in its fruits. *E. americana* is a 5 m tall tree and its branches are widely spread. *E. caribaea* and *E. indica* are medium sized tree, normally grow 6 - 9 m in height and its leaves are trifoliate, bright-emerald green. *E. latissima* is 9 - 24 m in height with root and stem burnt (Wanjala *et al*., 2002). *E. melanacantha* has smaller leaves and shorter, standard calyx (Gillett, 1972). *E. mildbraedii* grows upto 30 m in height and is native in West Africa. *E. poeppigiana* is a roadside tree having 8 - 12 m height with orange colored flowers (Tanaka *et al*., 2003). *E. stricta* Roxb is a midsize tree with cracked cork bark having pale yellow prickle branches (Hussain *et al*., 2011). *E. subumbrans* is a deciduous, medium sized tree (5 - 25 m tall). Three leaflets are present in leaves at alternate arrangement and its bark is whitish. *E. variegata* is a first growing deciduous tree with 15-18 m tall and leaves are 6 inches long having spiny branches (Kumar *et al*., 2010). *E. vespertilio* is an ambiguous tree (common name: bean tree) and indigenous to North Australia. *E. velutina* is a leguminous tall tree that grows upto 10 m and indigenous to Brazil.

E. zeberi and *E. zeyheri* are deciduous subshurb trees growing upto 60 cm height having glabrous, trifoliolate leaves with large leaflets armed. The species of *Erythrina* have been used as traditional medicaments as sedative, antiasthmatic, antiepileptic, anticonvulsant, antipyretic, antiinflammation, antibacterial, insomnia, helminthiasis, cough, cuts and wounds (Kumar *et al.*, 2010).

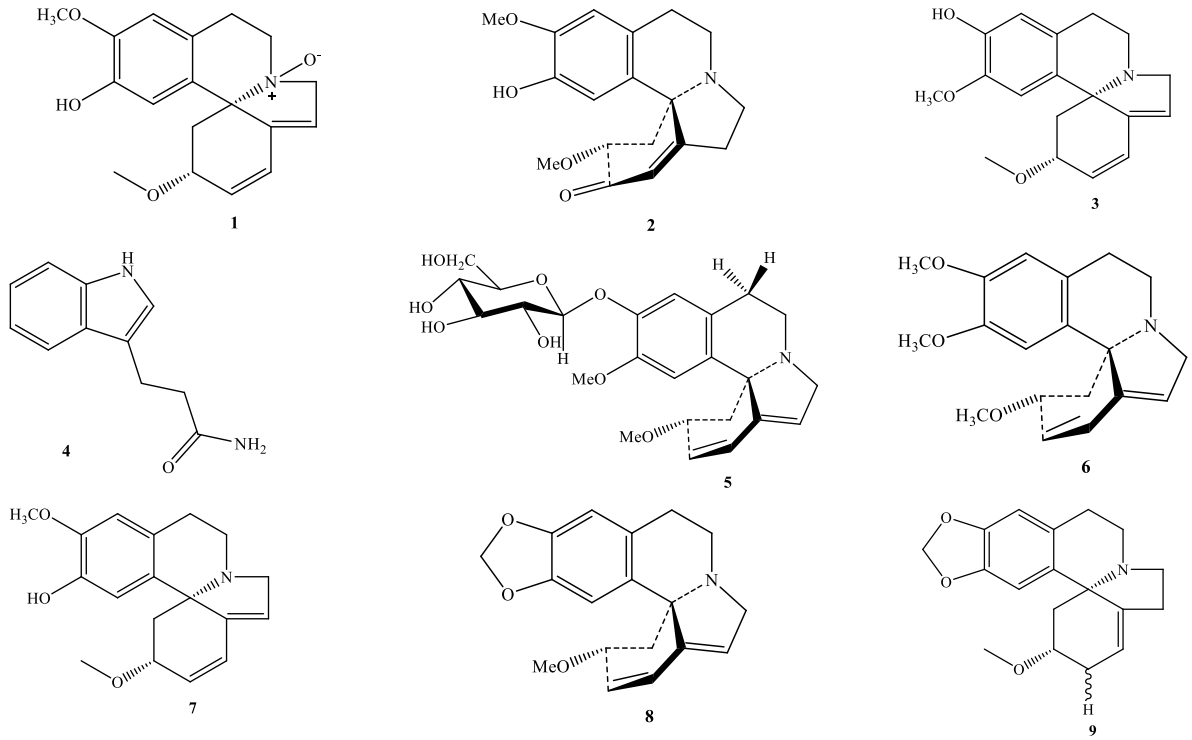
Although some reviews carring chemical constituents of particular *Erythrina* species have been found, no detailed review was found on different *Erythrina* species. Thus, this paper will assist the researchers working on *Erythrina* species around the globe.

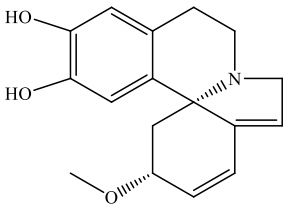
Phytoconstituents

A total of 15 species of *Erythrina* have been analyzed and 155 (**1-155**) molecules were reported in this review as phytoconstituents. The species are *E.*

Correspondence to: Mohammad Musarraf Hussain; Email: m.musarraf.hussain@gmail.com

addisoniae, E. caribaea, E. indica, E. lattisima, E. melanacantha, E. mildbraedii, E. poeppigiana, E. stricta, E. subumbrans, E. veriagata, E. vespertilio, E. velutina, E. zeberi, E. zeyheri and *E. americana.* Different chemical constituents such as – alkaloids, flavonoids, pterocarpans, triterpenes and steroids were extracted from these compounds. *Erythrina* is a prominent source of alkaloid. A bunch of alkaloids are isolated from these fifteen species of *Erythrina* such as - Erysovine-*N*-oxide (**1**), Erysosalvinone (**2**), Erysodine (**3**), 1*H*-indole-3-propanamide (**4**), Glucoerysodine (**5**), Erysotrine (**6**), Erysovine (**7**), Erythraline (**8**), Erythramine (**9**), Erysopine (**10**), Erythrocarine (**11**), Erythrinine (**17**), 10, 11-Dioxyerysotrine (**34**), Erysosalvine (**41**), Erymelanthine (**43**), Melanacanthine (**43**), 8-Oxa-*α*-erythroidine (**54**), 8-Oxo-*α*-erythroidine epoxide (**61**), 8-Oxo-*α*-erythroidine (**62**), 8-Oxo-erythraline epoxide (**63**), 11-Hydroxyepierythratidine (**66**), Erythrinan (**67**), 11-Acetryl erysotrine (**68**), Erythratidinone (**69**), 10,11-dioxo- erythrartine (**79**), 10,11-dioxoepierythrstidine (**80**), 10,11-erythratidinone (**81**), Epierythratine (**94**), 11-Hydroxyerythratine (**95**), 11-Hydroxyepierythratine (**96**), Erythritol (**99**), Isococolinine (**103**), Erythratidinone (**106**), Demethoxyerythratidinone (**107**), Erythramine (**108**), Erysopitine (**109**), Erysodienone (**110**), 11-Methoxyerythraline (**141**) and E-erythsotin (**142**), Sodium erysovine 15-*O*-sulfate (**143**), Erysopine 15-*O*-sulfate (**144**), 16-*O*-*β*-D-Glucopyranosyl coccoline (**145**), Sodium erysovine *N*-oxy-15-*O*-sulfate (**146**), 11-Oxoerythraline (**147**), *β*-erythroidine (**153**), Dihydro-*β*-erythroidine (**154**) and Wilsonine (**155**) (Figure 1) (Amer *et al*., 1991; Boland *et al*., 1998; Cui *et al*., 2009; Faria *et al*., 2007; Garin-Aguilar *et al*., 2000; Haggins *et al*., 1981; Hauschild *et al*., 2010; Hussain, 2002; Jang *et al*, 2008; Kabenei *et al*., 2011; Kumar *et al*., 2010; Soto-Hernadez *et al*., 2012; Lundquist, 1973; Miyazawa *et al*, 2006; Nakayama *et al*, 1978; Ozawa *et al*., 2011; Rodriguez *et al*., 2004; Watjen *et al*., 2008; Rahman *et al*., 2007; Rahman *et al*., 2010; Rodriguez *et al*., 2004; Rukachaisirikul *et al*., 2007; Rukachaisirikul *et al*., 2008; Soto-Hernadez *et al*, 2012; Tanaka *et al*., 2001; Tanaka *et al*., 2003; Wanjala *et al*, 2002; Zheng *et al*., 2013; Zhou *et al*., 2011).





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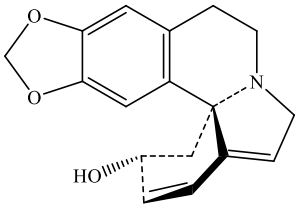

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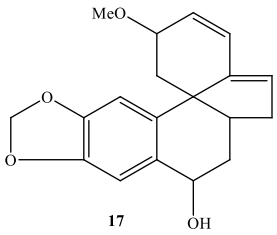

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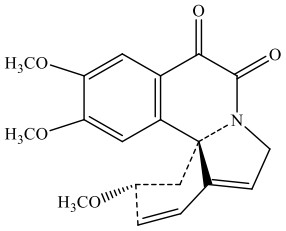

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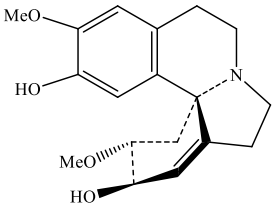

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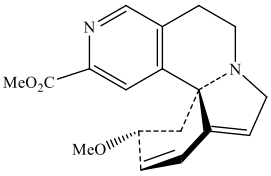

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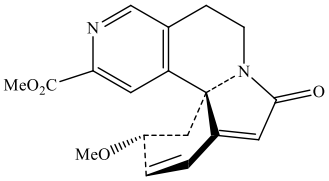

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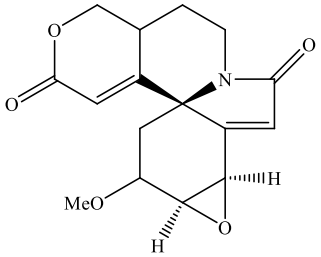

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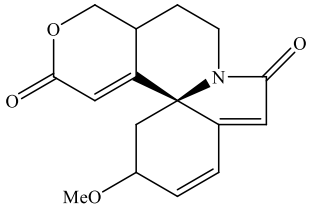

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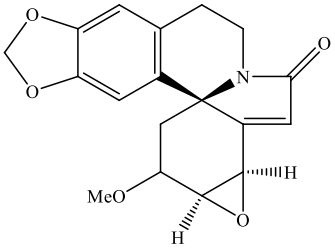

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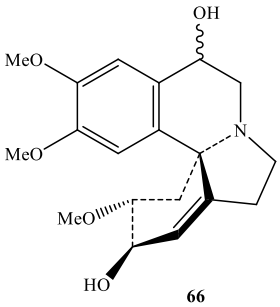

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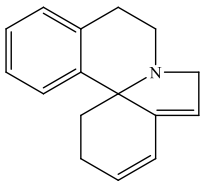

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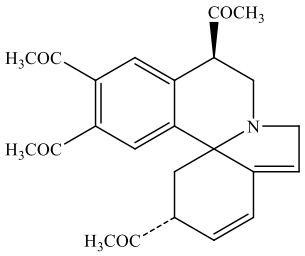

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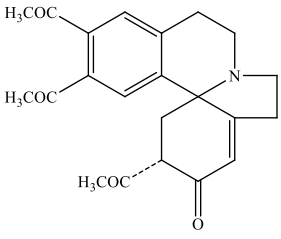

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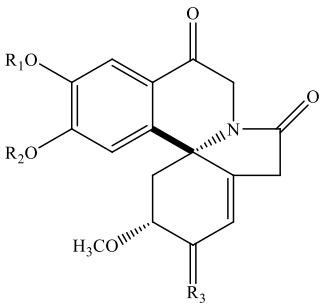
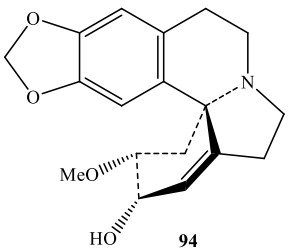


79: R_1+ R_2 = CH_2, R_3 = Beta-OH, H
80: R_1 = R_2 = CH_3, R_3 = Beta-OH, H
81: R_1 = R_2 = CH_3, R_3= O



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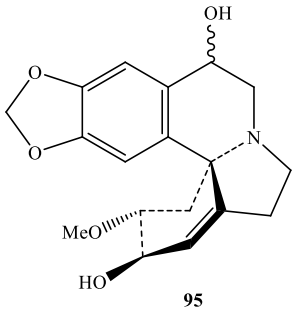

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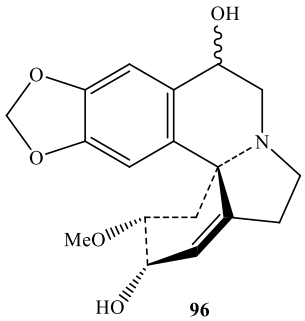

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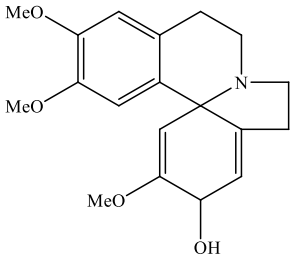

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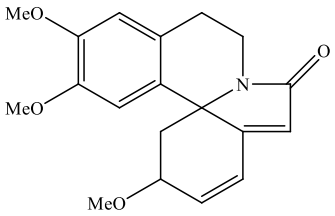

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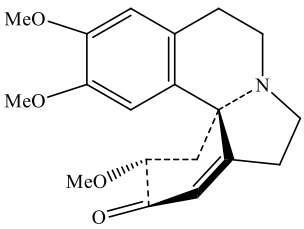

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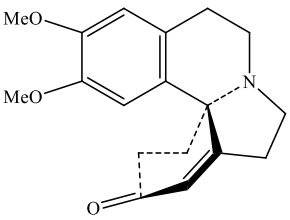

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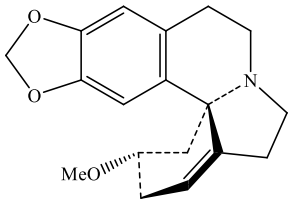

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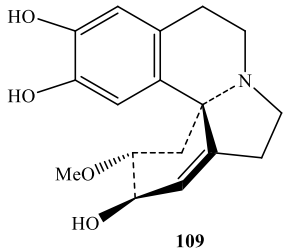

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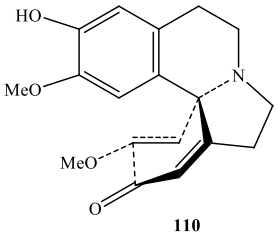

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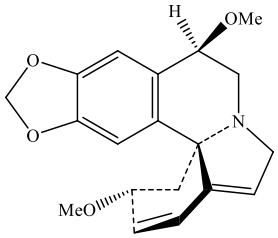

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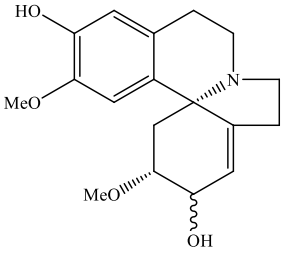

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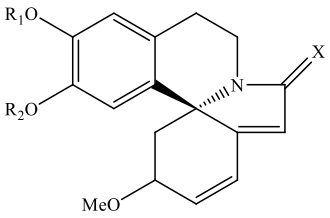
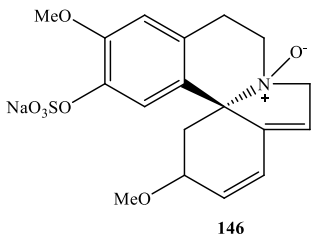


143: R_1 = Me, R_2 = SO_3Na, X = H_2
144: R_1 = H, R_2 = SO_3H, X = H_2
145: R_1 = Beta-D-Glc, R_2 = Me, X = O



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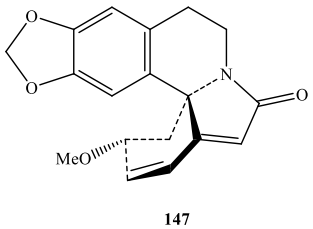

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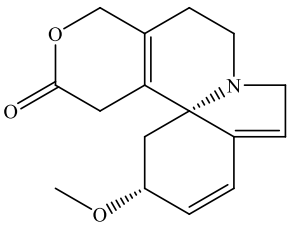

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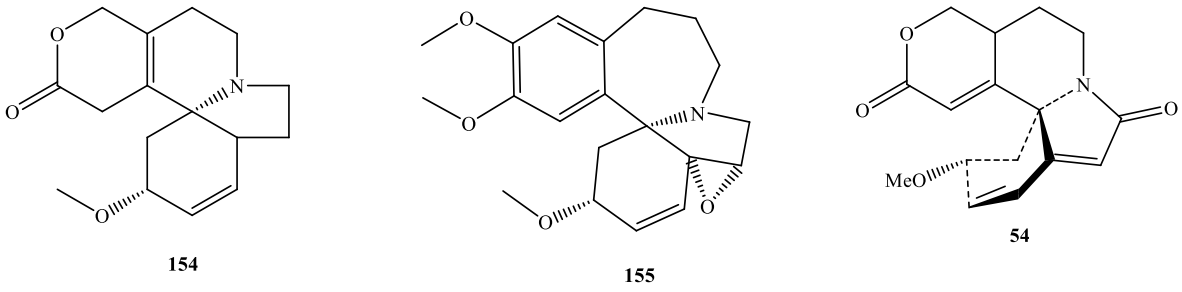
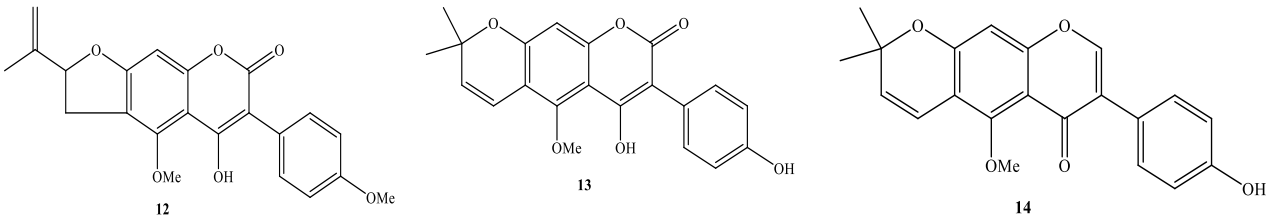
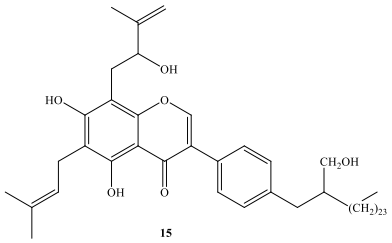


Figure 1. Alkaloids from different species of *Erythrina.*

Many falvonoids have been derived from these 15 species of *Erythrina* such as - Indicanine A (**12**), Indicanine B (**13**), Indicanine C (**14**), Indicanine D (**15**), Indicanine E (**16**), Wighteone (**18**), Alpinumisoflavone (**19**), Dimethylalpinumisoflavone (**20**), Erythrinin C (**21**), Erysenegalensein E (**22**), Abyssinone IV (**28**), Erylatissin A (**29**), Erylatissin B (**30**), Erylatissin C (**31**), Erythrinin B (**33**), Neobavaisoflavone (**37**), Licoflavone-4´-O-methyl ether (**44**), 2´,7-Dihydroxy-4´-methoxy-5´-(3-methylbut-2-enyl)isoflavone (**45**), (3R)-2´,7-Dihydroxy-3´-(3-methylbut-2-enyl)-2´´´, 2´´´ dimethylpyrano [5´´´,6´´´,4´,5´] isoflavan (**46**), Abyssinin II (**47**), Parvisoflavone B (**48**), Erypoegin G (**50**), Erysubin F (**57**), 5-Hydroxysophoranone (**75**), Abyssinone V (**78**), Lespedezaflavanone B (**87**), Glabrol (**91**), Vogelin C (**93**), Erythrinins A (**100**), 6-Hydroxygenistein (**101**), Eryvarin B (**111**), Eryvarin F (**112**), Eryvarin M (**114**), Eryvarin N (**115**), Eryvarin O (**116**), Scandenone (**123**), 5,7,4´-trihydroxy-6,8-diprenylisoflavone (**124**), 4´,5,7-Trihydroxy-8-prenylisoflavone (**125**), 4´,5,7-Trihydroxy-8-methylisoflavone (**126**), Isobavachin (**128**), 5,4´-Dihydroxy-8-(3,3-dimethylallyl)-2´´-methoxyisopropyl furano[4,5:6,7]isoflavone (**132**), 5,7,4´-Trihydroxy-6-(3,3- dimethylallyloxiranylmethyl) isoflavone (**133**), 5,4´-Dihydroxy-8-(3,3-dimethylallyl)-2´´-hydroxy-methyl-2´´-methylpyrano[5,6:6,7] isoflavone (**134**), 5,4´-Dihydroxy-2´-methoxy-8-(3,3-dimethyl-allyl)-2´´,2´´-dimethylpyrano[5,6:6,7] isoflavone (**135**), Euchrenone b_{10} (**136**), Isoerysenegalensein E (**137**), Laburnetin (**138**), Lupiwighteone (**139**), Eryzerin A (**148**), Eryzerin B (**149**), Eryzerin C (**150**), Eryzerin D (**151**) (Figure 2) (Boland *et al*., 1998; Chacha *et al.*, 2005; Hussain *et al*., 2008; Hussain *et al*., 2011; Jang *et al*., 2008; Kobayashi *et al*., 1997; Koo *et al*., 2013; Kumar *et al*., 2010; Lundquist, 1973; Miyazawa *et al.*, 2006; Nakayama *et al.*, 1978; Nkengfack *et al*., 2001; Rahman *et al*., 2007; Rahman *et al*., 2010; Rodriguez *et al*., 2004; Rukachaisirikul *et al*., 2007; Rukachaisirikul *et al*., 2007; Sato *et al*., 2003; Soto-Hernadez *et al*., 2012; Talikepali *et al*., 1990; Tanaka *et al*., 2001; Tanaka *et al*., 2002; Tanaka *et al*., 2003; Tanaka *et al*., 2004; Tanaka *et al*, 2011; Tchokouaha *et al*., 2010; Waffo *et al*., 2000; Wanjala *et al*., 2002; Watjen *et al*., 2008; Xiaoli *et al*., 2006; Zheng *et al*., 2013; Zhou *et al*., 2011).





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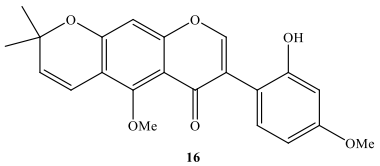

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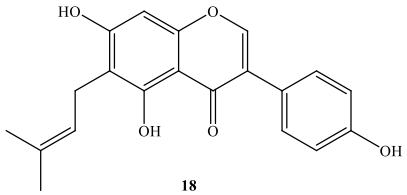

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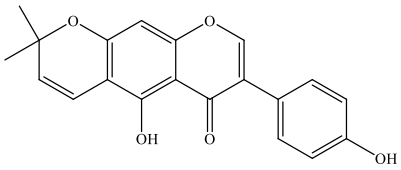

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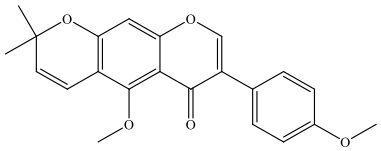

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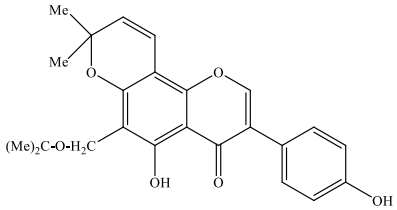

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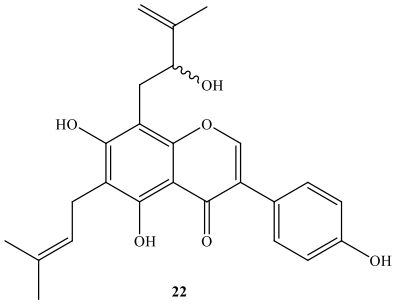

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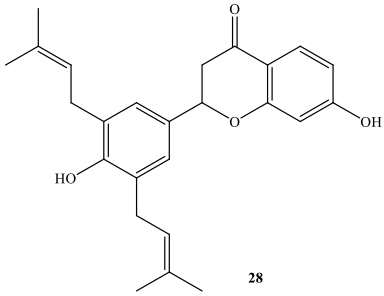

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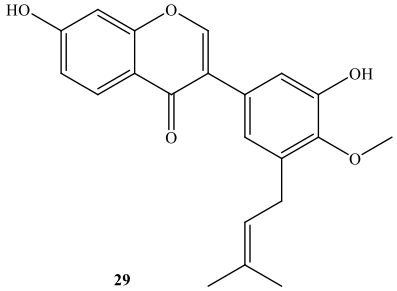

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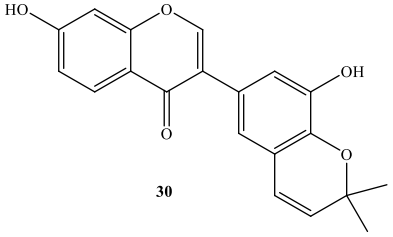

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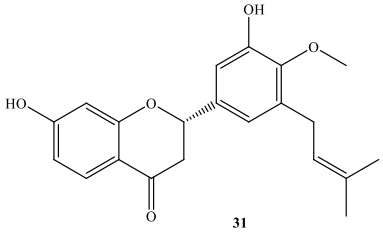

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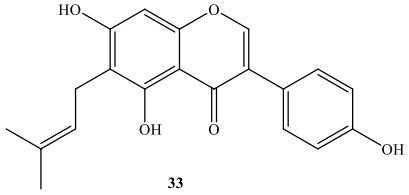

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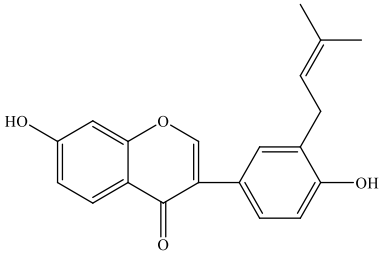

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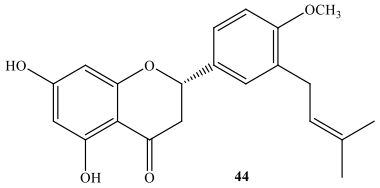

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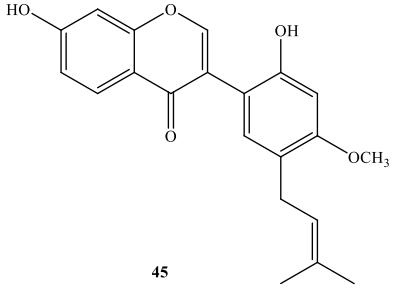

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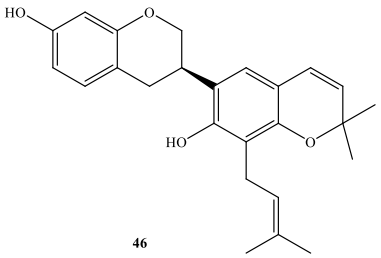

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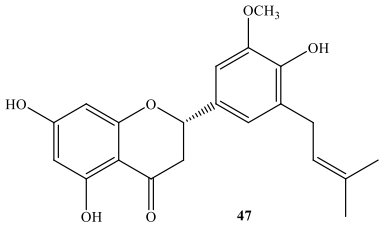

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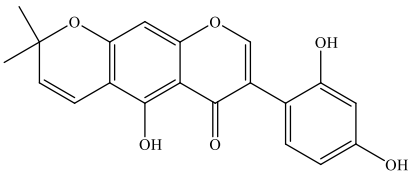

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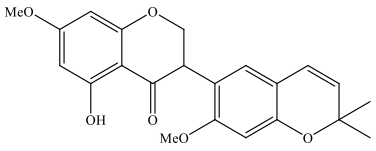

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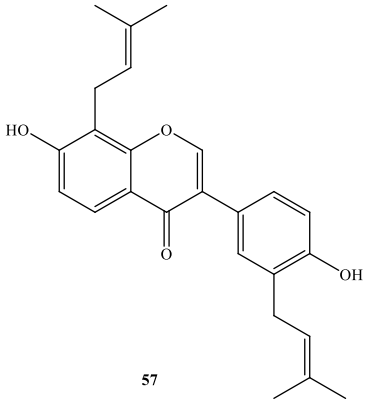

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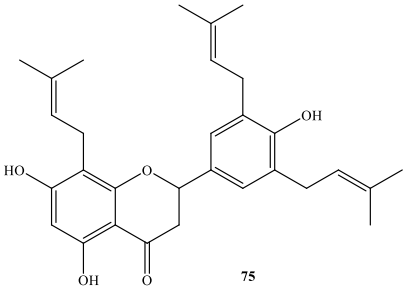

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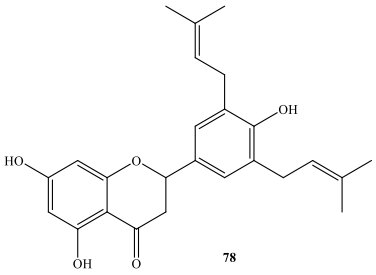

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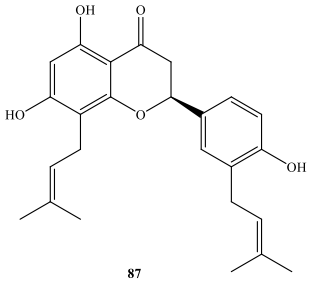

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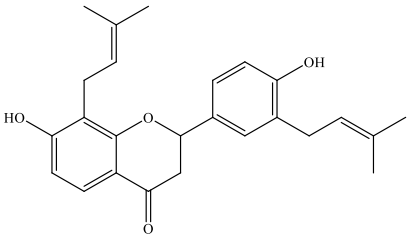

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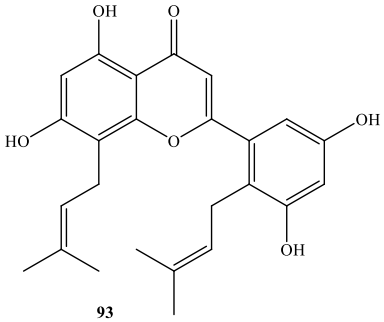

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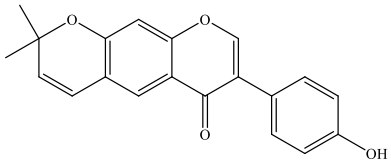

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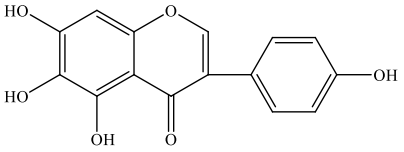

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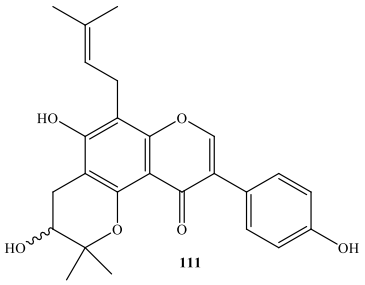

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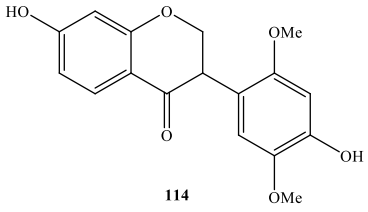

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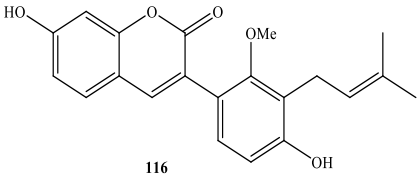

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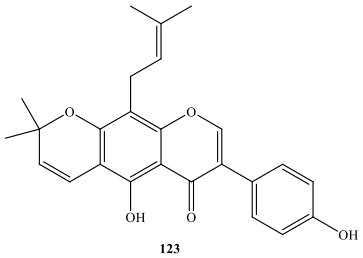

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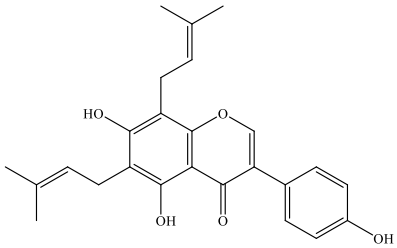

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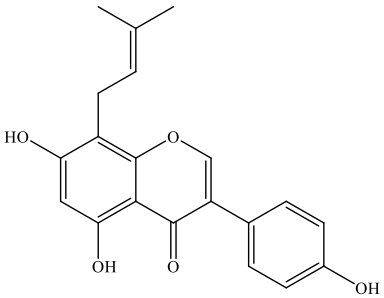

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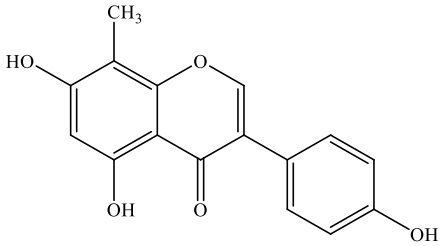

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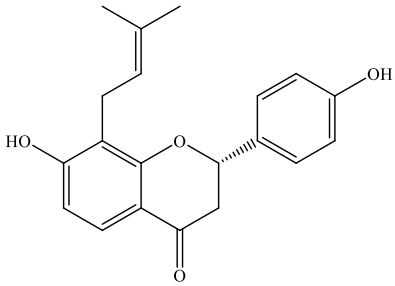

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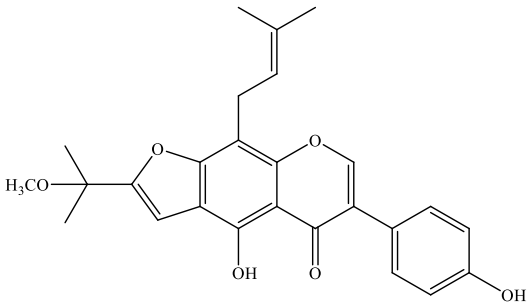

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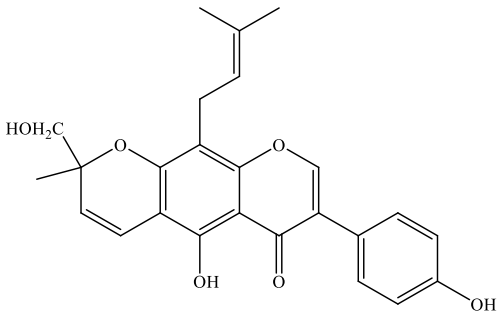

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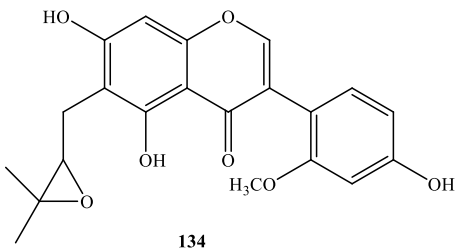

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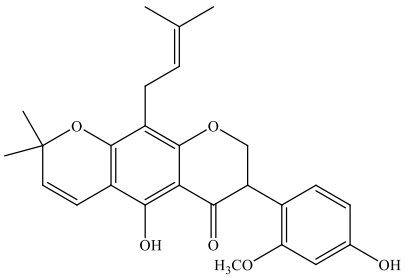

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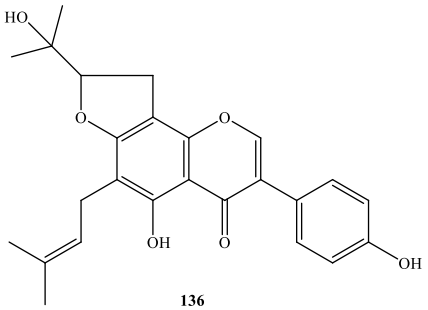

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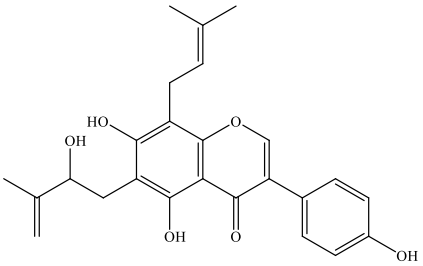

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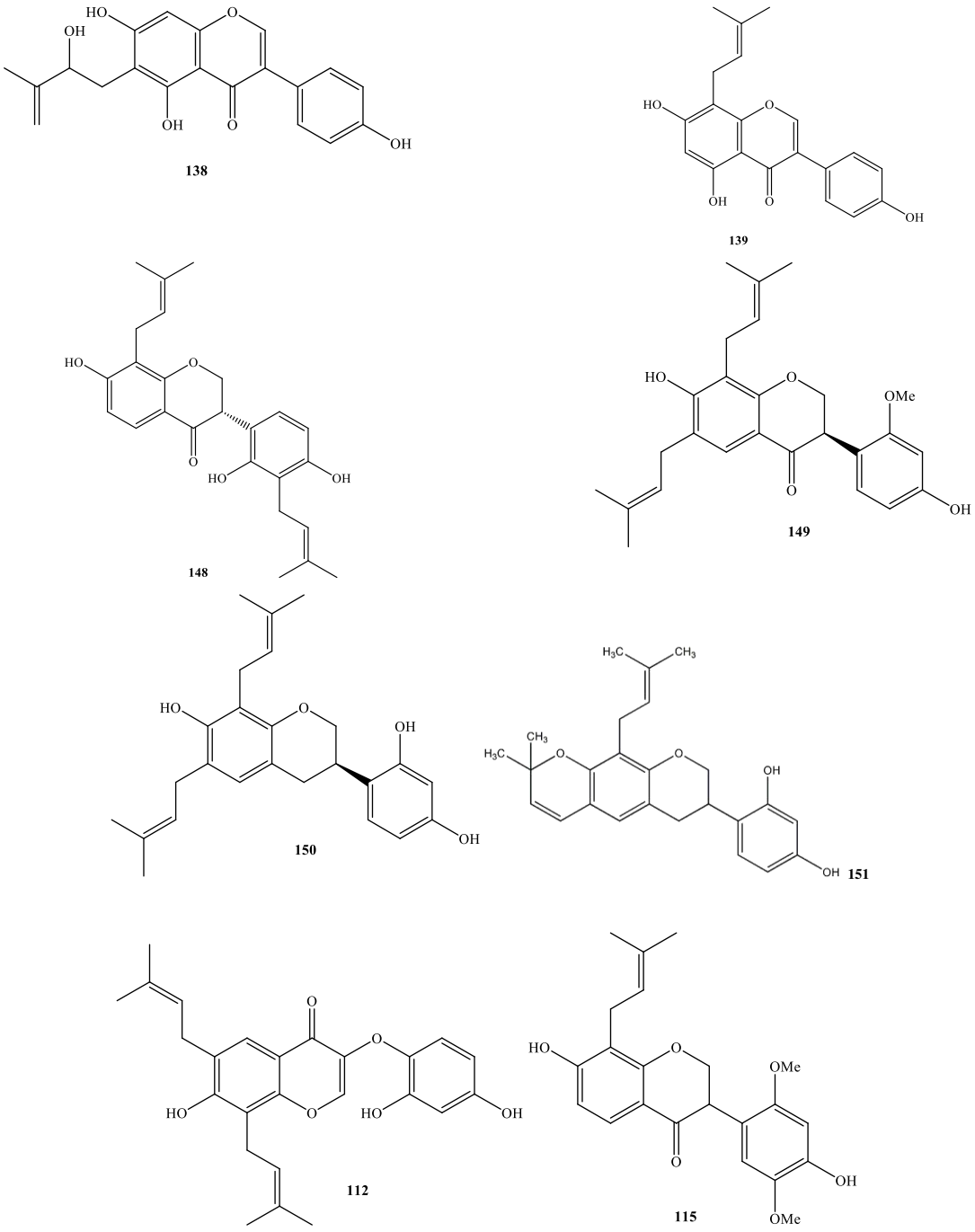
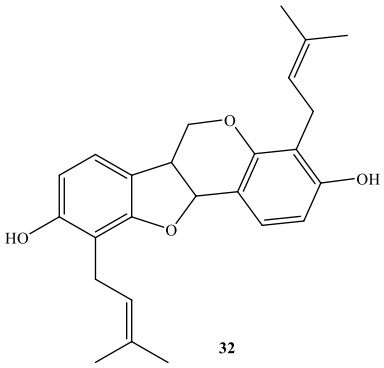


Figure 2. Flavonoids reported from *Erythrina* species.

The plant belonging to the genus *Erythrina* contain a number of pterocarpans such as - Erybraedin A (**32**), 2-(5´-Hydroxy-3-methoxyphenyl)-6-hydroxy-5-methoxybenzofuran (**35**), Isoneorautenol (**38**), Erymelanthine (**42**), Erypoegin F (**49**), Erypoegin H (**51**), Erypoegin I (**52**), Erypoegin J (**53**), Cristacaprin (**55**), Dimethylmedicaprin (**56**), Eryvarin D (**58**), Folitenol (**59**), Erystagallin C (**64**), Eryvarin A (**65**), Erystagallin A (**76**), Erycristagallin (**77**), 1-Methoxyerythrabissin (**82**), Erythrabissin-I (**83**), Erythrabissin-II (**84**), Erybraedin B (**85**), Hydroxycristacarpone (**86**), Phaseollin (**89**), Eryvarin E (**90**), Dihydrofolinin (**97**), Orientanol-B (**104**), Phaseollidin (**127**) and Eryzerins E (**152**) (Figure 3) (Amir *et al*., 2011; Boland *et al*., 1998;

Hauschild *et al.*, 2010; Innok *et al*., 2010; Kabenei *et al*., 2011; Kobayashi *et al*., 1997; Lundquist, 1973; Miyazawa *et al.*, 2006; Soto-Hernadez *et al*., 2012; Rahman *et al*., 2007; Rukachaisirikul *et al*., 2007; Rukachaisirikul *et al*., 2008; Tanaka *et al*., 1996; Tanaka *et al*., 2002; Tanaka *et al*., 2002; Zheng *et al*., 2013; Zhou *et al*., 2011).



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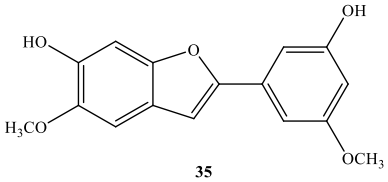

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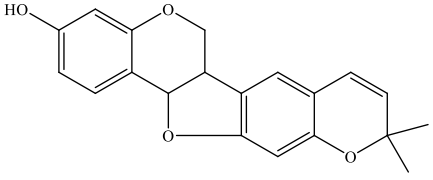

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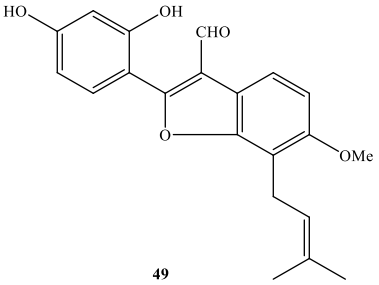

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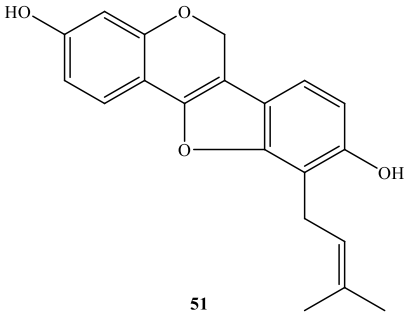

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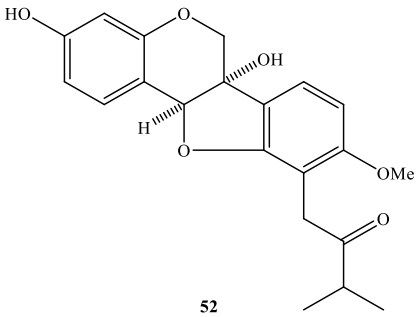

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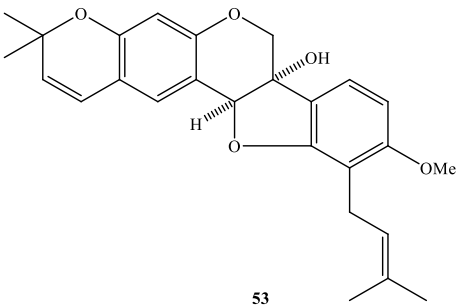

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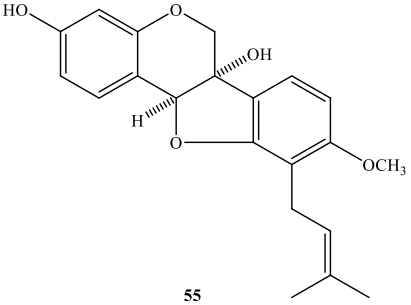

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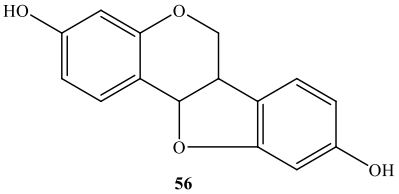

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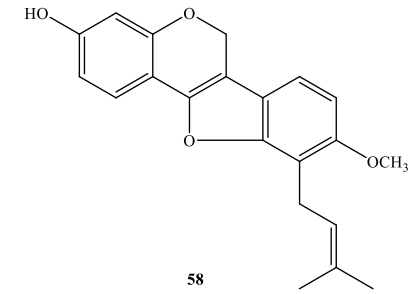

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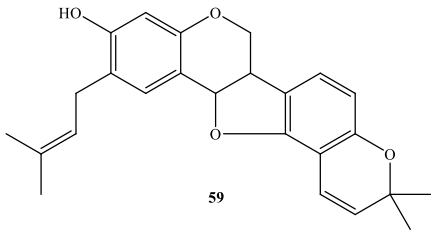

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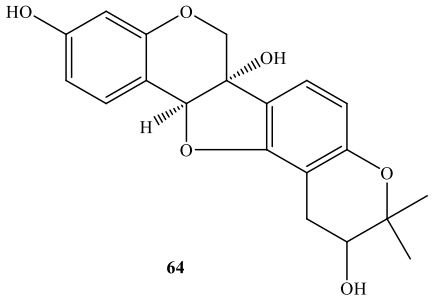

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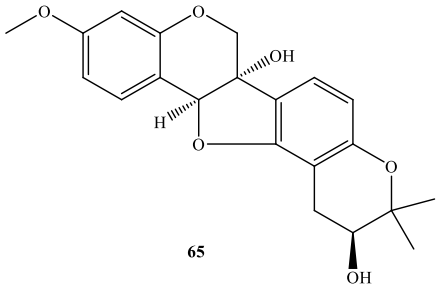

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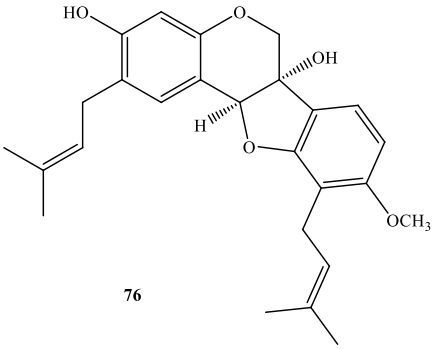

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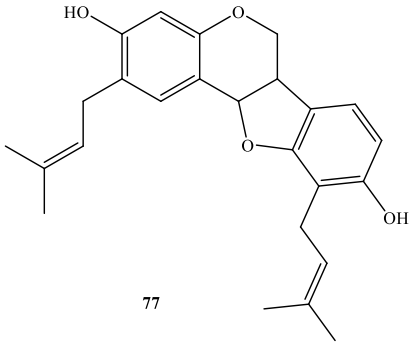

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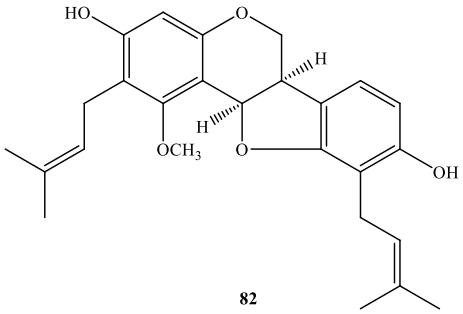

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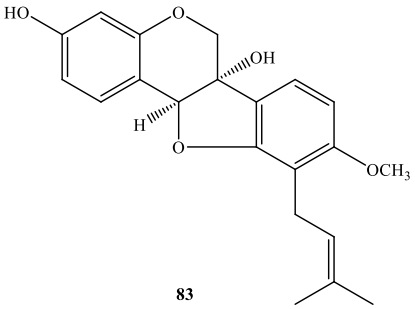

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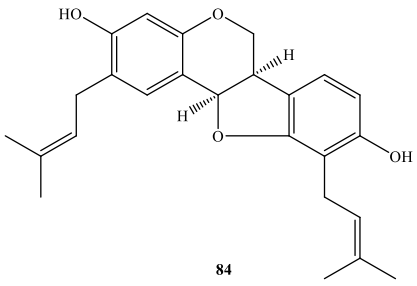

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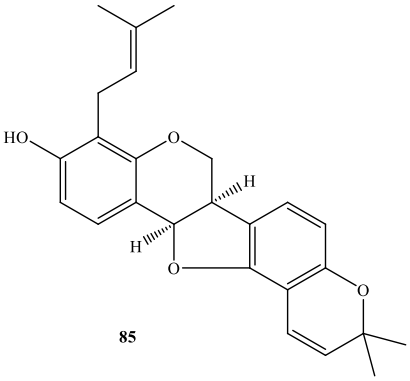

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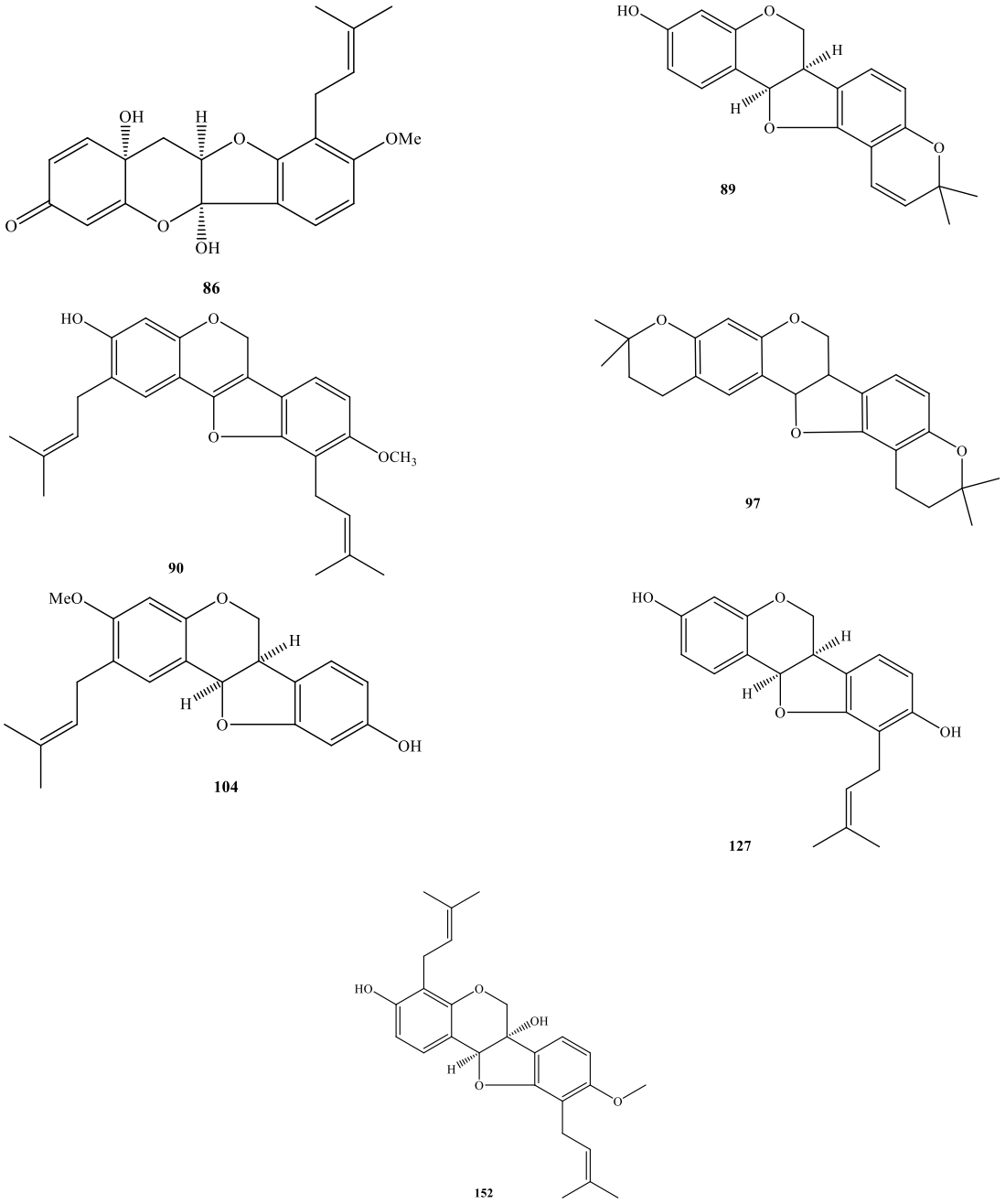


Figure 3. Pterocarpans from fifteen species of *Erythrina.*

Erithrina species contain some triterpenes and steroids. These are - Oleanolic acid (**24**), Erythrodiol (**25**), Stigmasterol (**26**), Sophoradiol (**70**), Stigmasta-4-en-3-one (**71**), Stigmasta-4,22-dien-3-one (**72**), 3*β*-hydroxystigmasta-5,22-dien-7-one (**73**), Melilotigenin C (**74**), Lupeol (**88**), Soyasapogenol B (**92**), Epilupeol (**98**) and 3*β*-28-dihydroxyolean-12-ene (**102**) (Figure 4) (Amir *et al*., 2011; Boland *et al*., 1998; Hauschild *et. al.*, 2010; Kobayashi *et al*., 1997; Lundquist, 1973; Miyazawa *et al.*, 2006; Soto-Hernadez *et al*., 2012; Tanaka *et al*., 2002; Zheng *et al*., 2013; Zhou *et al*., 2011).

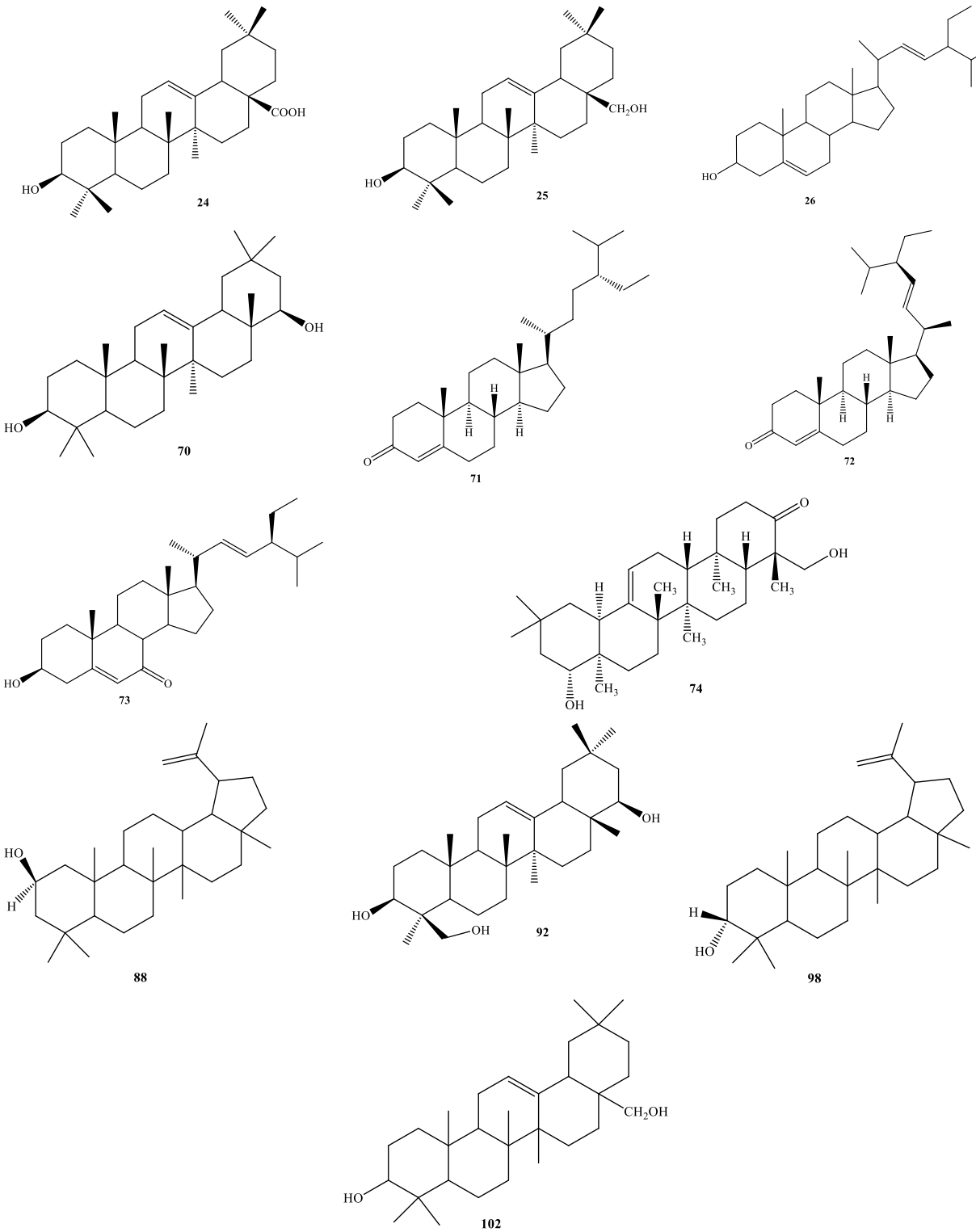
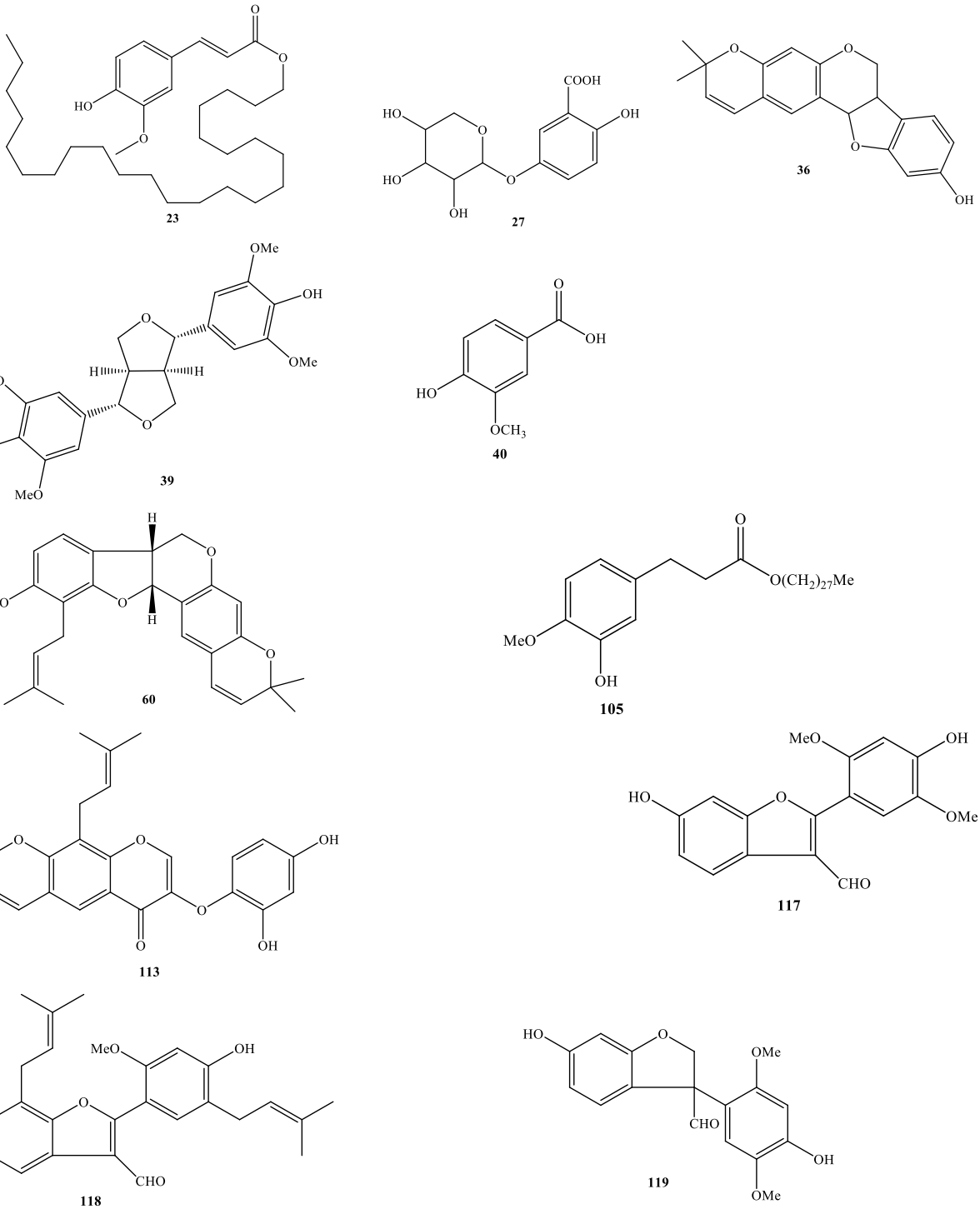


Figure 4. Triterpenes and steroids from different species of *Erythrina.*

A good number of miscellaneous classes of compounds were also extracted from these fifteen species of *Erythrina*, including Erythrinassinate B (**23**), 5-*O*-*β*-D-xylo-pyranoside (**27**), Neorautenol (**36**),

Syringaresinol (**39**), Vanillic acid (**40**), Orientanol C (**60**), Octacosyl ferulate (**105**), Eryvarin G (**113**), Eryvarin P (**117**), Eryvarin Q (**118**), Eryvarin R (**119**), Eryvarin V (**120**), Eryvarin W (**121**), Eryvarin X (**122**), Eryvaiestyrene (**129**), Eryvarinol A (**130**), Eryvarinol B (**131**), Eryvarin H (**140**) (Figure 5) (Amir *et al*., 2011; Boland *et al*., 1998; Koo *et al*., 2013; Lundquist, 1973; Miyazawa *et al*., 2006; Rahman *et al*., 2007; Soto-Hernadez *et al*., 2012; Zheng *et al*., 2013; Zhou *et al*., 2011).



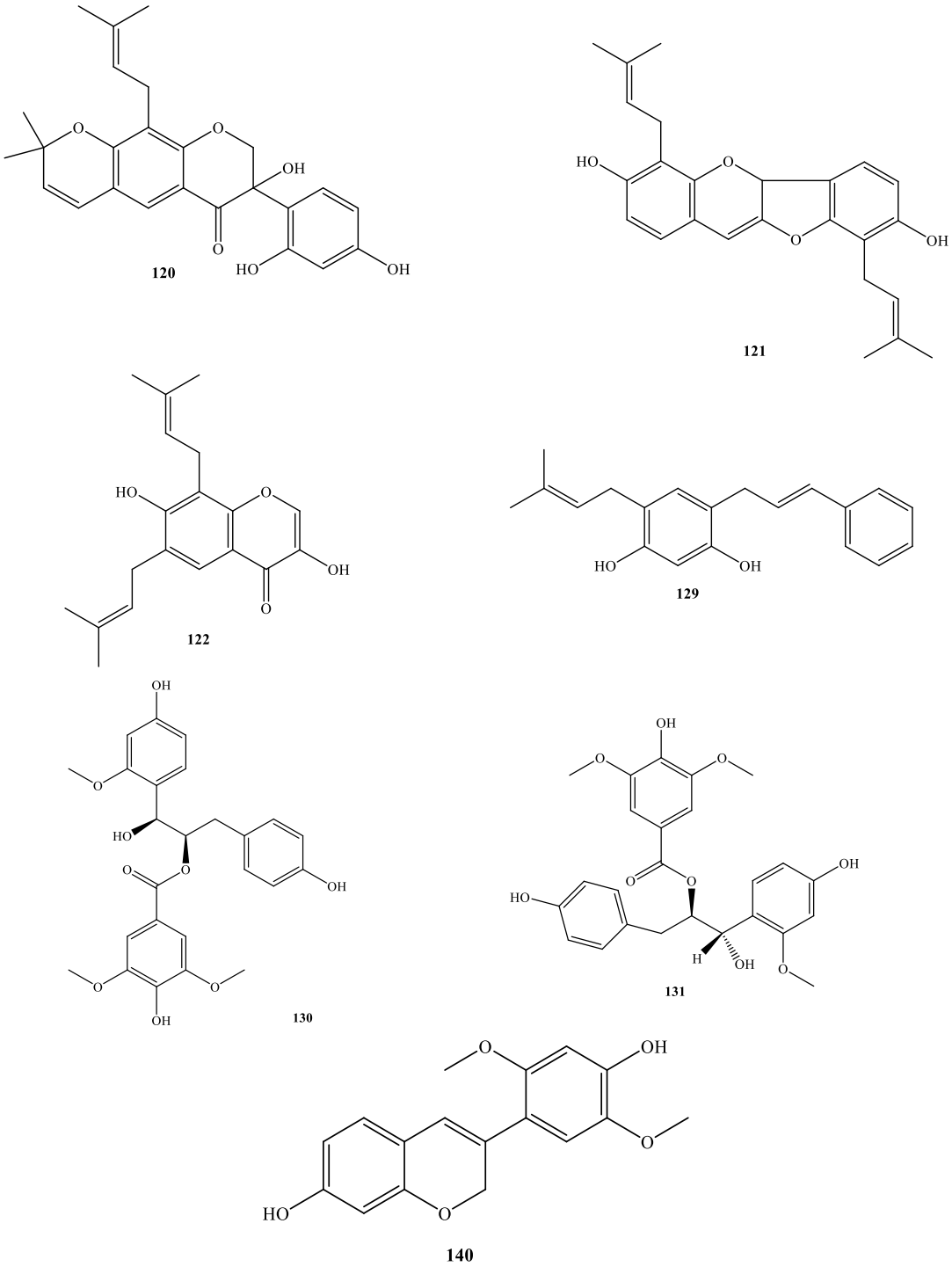


Figure 5. Miscellaneous chemical constituents from *Erythrina* species.

Conclusion

The chemical compounds from 15 species of *Erythrina* have been reviewed. Structurally unique along with many diversified compounds have been observed from this genus. Our study revealed that *Erythrina* can be a prominent source of phytoconstituens as well as medicinal agents, and therefore other species of this genus need to be investigated for secondary metabolites.

References

Amer, M.E., Shamma, M. and Freye, A.J. 1991. The tetracyclic *Erythrina* alkaloids. *J. Nat. Prod*. **54**, 329-363.

Amir, F., Yam, W.S. and Koay, Y.C, 2011. Phytochemical constituents and biological activities of *Erythrina indica*. *European J. Chem.* **2**, 561-565.

Boland, G.M. and Donnelly, D.M.X. 1998. Isoflavonoids and related compounds. *Nat. Prod. Rep.* 241-260.

Chacha, M., Moleta, G.B. and Majinda, R.R.T. 2005. Antimicrobial and radical scavenging flavonoids from the stem wood of *Erythrina latissima*. *Phytochemistry* **66**, 99-104.

Cui. L., Thuong, P.T., Fomum, Z.T. and Oh, W.K. 2009. A new erythrinan alkaloid from the seed of *Erythrina addisoniae*. *Arch. Pharmacal. Res.* **32**, 325-328.

Faria, T.D.J., Cafeu, M.C., Akiyoshi, G., Ferreira, D.T., Galao, O.F., Andrei, C.C., Pinge-Filho, P., Paiva, M.R.C., Barbosa, A.D.M. and Braz-Filho, R. 2007. Alkaloids from flowers and leaves of *Erythrina speciosa* Andrews. *Quimica Nova.* **30**, 525-527.

Folkers, K. and Major, R.T. 1937. Isolation of Erythroidine, an alkaloid of curare action from *Erythrina americana* Mill. *J. Am. Chem. Soc.* **59**, 1580.

Garin-Aguilar, M.E., Ramirez-Luna, J.E., Soto-Hernandez, M., Valencia, D.T.G. and Martinez-Vazquez, M. 2000. Effect of crude extracts of *Erythrina americana* Mill. on aggressive behavior in rats. *J. Ethnopharmacol*. **69**, 189.

Gillett, J.B. 1972. A further note on *Erythrina melanacantha* (Leguminosae-Papilionoideae), including a new subspecies from Somalia. *Kew Bull.* **27**, 289-291.

Haggins, V. J. and Ingham, J.L. 1981. Demethylmedicaprin, a product formed from medicaprin by *Colletotrichum coccodes*. *Phytopathology* **71**, 800-803.

Hauschild, W., Mutiso, P.B. and Passreiter, C.M., 2010. Prenylated pterocarpanes from *Erythrina melanacantha*. *Nat. Prod. Commun.* **5,** 721-724.

Hussain, M.M., Dastagir, M.G., Billah, A.H.M.M. and Ismail, M. 2011. Alpinum isoflavone from *Erythrina stricta* Roxb. *Bol. Latinoam. Caribe. Plant Med. Aromat.* **10**, 88-90.

Hussain, S.S., 2002. A new alkaloids from flowers of *Erythrina stricta. J. Sci. I. R. Iran.* **13**, 35-38.

Hussain, M.M., Rahman, M.S., Jabbar, A. and Rashid, M.A. 2008. Phytochemical and biological investigation of *Albizzia lebbeck*. *Bol. Latinoam. Caribe Plant Med. Aromat.* **7,** 273-278.

Innok, P., Rukachaisirikul, T., Phongpaichit, S. and Suksamrarn, A. 2010. Fuscacarpans A-C, new pterocarpans from the stems of *Erythrina fusca*. *Fitoterapia.* **81**, 518-23.

Jang, J.P., Na, M.K., Thoung, P.T., Njamen, D., Mbafor, J.T., Fomum, Z.T., Woo, E.R. and Oh, W.K. 2008. Prenylated flavanoids with PTP1B inhibitory activity from the root bark of *Erythrina mildbraedii*. *Chem. Pharm. Bull.* **56**, 85-88.

Kabenei, J.S., Ndalut, P.K. and Sabah, A.O. 2011. Synergism of artemisinin with abyssinone-V from *Erythrina abyssinica*, (Lam. ex) against *Plasmodium falciparum* parasites: A potential anti-malarial combination therapy. *J. Med. Plant Res.* **5**, 1355-1360.

Koo, J.Y., Oh, S., Cho, S.R., Koh, M., Oh, W.K., Choi, H.S. and Park, S.B. 2013. Total synthesis of Eryvarin H and its derivatives and their biological activity as ERRγ inverse agonist. *Org. Biomol. Chem.* **11**, 5782-5786.

Kobayashi, M., Mahmud, T., Yoshioka, N., Shibuya, H. and Kitagawa, I., 1997. Indonesian medicinal planst XXI. Inhibitors of Na^+/H^+ exchanger from the bark of *Erythrina variegata* and the roots of *Maclura cochinchinensis*. *Chem. Pharm. Bull.* **45**, 1615-1619.

Kumar, A., Lingadurai, S., Jain, A. and Barman, N.R. 2010. *Erythrina variegata* Linn: A review on morphology, phytochemistry, and pharmacological aspects. *Pharmacog. Rev.* **4**, 147-152.

Lundquist, K. 1973. Acid degradation of Lignin. *Acta Chem. Scan.* **27**, 2597-2606.

Miyazawa, M., Utsunomiya, H., Inada, K., Yamada, T., Okuno, Y., Tanaka, H. and Tatematsu, M. 2006. Inhibition of *Helicobacter pylori* motility by (+)-syringaresinol from unripe Japanese apricot. *Chem. Pharm. Bull.* **29**, 172-173.

Nakayama, M., Eguchi, S., Hayashi, S. and Tsukayama, M. 1978. The synthesis of neobavaisoflavone and related compounds. *Chem. Pharm. Bull.* **51**, 2398-2400.

Nkengfack, A.E., Azebaze, A.G..B., Waffo, A.K., Fomum, Z.T., Meyer, M. and Heerden, F.R. 2001. Cytotoxic isoflavonoids from *Erythrina indica Phytochemistry* **58**, 1113-1120.

Ozawa, M., Kishida, A. and Ohsaki, A. 2011. Erythrinan alkaloids from seeds of *Erythrina velutina*. *Chem. Pharm. Bull.* **59**, 564-567.

Rahman, M.Z., Rahman, M.S., Kaisar, A., Hossain, A. and Rashid, M.A. 2010. Bioactive isoflavones from *Erythrina variegata* L. *Turk. J. Pharm. Sci.* **7**, 21-28.

Rahman, M.Z, Sultana, S.J., Faroque, C.F., Ferdous, F., Rahman, M.S., Islam, M.S. and Rashid, M.A. 2007. Phytochemical and Biological investigation of *Erythrina variegata*. *Saudi Pharm. J.* **15**, 140-145.

Rodriguez, R.R., Herrera, M.D., Perona, J.S. and Gutierrez, V.R. 2004. Potential vasorelaxant effects of oleanolic acid and erythrodiol two triterpenoids contained in "orujo" olive oil, on rat aorta. *British J. Nut.* **92**, 635-642.

Rukachaisirikul, T., Innok, P., Aroonrerk, N., Boonamnuaylap, W., Limrangsun, S., Boonyon, C., Woonjina, U. and Suksamrarn, A. 2007. Antibacterial pterocarpans from *Erythrina subumbrans*. *J. Ethnopharmacol.* **110**, 171-175.

Rukachaisirikul, T., Saekee, A., Tharibun, C., Watkuolham, S. and Suksamrarn, A. 2007. Biological activities of the chemical constituents of *Erythrina stricta* and *Erythrina subumbrans*. *Arch. Pharmacal. Res.* **30**, 1398-1403.

Rukachaisirikul, T., Innok, P. and Suksamrarn, A. 2008. Erythrina alkaloids and a pterocarpens from the bark of *Erythrina subumbrans*. *J. Nat. Prod.* **71**, 156-158.

Sato, M., Tanaka, H., Fujuwara, S., Hirata, M., Yamaguchi, R., Etoh, H. and Tokuda, C. 2003. Antibacterial property of isoflavanoids isolated from *Erythrina variegata* against cariogenic oral bacteria. *Phytomedicine* **10**, 427-433.

Soto-Hernandez M.R., Garcia-Mateos R., Migual-Chavez R.S. and Ramos-Valdivia C. 2012. *Erythrina*, a potential source of chemical from the Neotropics. *Bioactive compounds in Phytomedicine*, 163-184.

Talekepalli, H., Gollapudi, S.R., Shokri, A.K., Velazquez, L., Sandmann, R.A., Veliz, E.A., Rao, K.V.J., Madhavi, A.S. and Mitscher, L.A. 1990. Isoflavanoids and a cinnamyl phenol from root extracts of *Erythrina variegata*. *Phytochemistry* **29**, 2005-2007.

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

Tanaka, H., Hirata, M., Etoh, H., Sako, M., Sato, M., Murata, J., Murata, H., Dedy, D. and Fukai, T. 2004. Six new constituents from the roots of *Erythrina variegata*. *Chem. Biodiversity* **1**, 1101-1108.

Tanaka, H., Tanaka, T. and Etoh, H. 1996. A pterocarpan from *Erythrina orientalis*. *Phytochemistry* **42**, 1473-1475.

Tanaka, H., Etoh, H., Shimizu, H., Oh-Uchi, T., Terada, Y. and Tateishi, Y. 2001. Erythrinan alkaloids and isoflavonoids from *Erythrina poeppigiana*. *Planta Med.* **67**, 871-873.

Tanaka, H., Hirata, M., Etoh, H., Shimizu, H., Sako, M., Murata, J., Murata, H., Darnaedi, D. and Fukai, T. 2003. Eryvarins F and G, two 3-phenoxychromones from the roots of *Erythrina variegata*. *Phytochemistry* **62**, 1243-1246.

Tanaka, H., Hirata, M., Etoh, H., Watanabe, N., Shimizu, H., Ahmad, M., Tareda, Y. and Fukai, T. 2002. Two diphenylpropan-1,2-diol syringates from the roots of *Erythrina variegata*. *J. Nat. Prod.* **65**, 1933-1935.

Tanaka, H., Oh-Uchi, T., Etoh, H., Sako, M., Sudo, M., Sato, M., Fukai, T. and Tateishi, Y. 2003. An arylbenzofuran and four isoflavonoids from *Erythrina poeppigiana*. *Phytochemistry* **63**, 597-602.

Tanaka, H., Sato, M., Fujiwara, S., Hirata, M., Etoh, H. and Takeuchi, H. 2002. Antibacterial activity of isoflavonoids isolated from *Erythrina variegata* against methicillin-resistant *Staphylococcus aureus*. *Lett. App. Microbio.* **35**, 494-498.

Tanaka, H., Uchi, T.O., Etoh, H., Sako, M., Asai, F., Fukai, T., Sato, M., Murata, J. and Tbateishi, Y. 2003. Isoflavonoids from roots of *Erythrina Zeyheri*. *Phytochemistry* **64**, 753-758.

Tchokouaha, R.F., Akexi, X., Chosson, E., Besson, T., Skaltsounis, A.L., Sequin, E., Alexis, M.N. and Wandji, J. 2010. Erymildbraedin A and B, two novel cytotoxic dimethylpyrano-isoflavones from the stem bark of *Erythrina mildbraedii*: evaluation of their activity toward endocrine cancer cells. *J. Enzyme Inhib. Med. Chem.* **25**, 228-233.

Waffo, A.K., Azebaze, A.G..B., Nkengfack, A.E., Fomum, Z.T., Meyer, M., Bodo, B. and Heerden, F.R. 2000. Indicanines B and C, two isoflavonoid derivatives from the root bark of *Erythrina indica*. *Phytochemistry* **53**, 981-985.

Wanjala, C.C.W., Juma, B.F., Bojase, G., Gashe, B.A. and Majinda, R.R.T. 2002. Erythrinaline alkaloids and antimicrobial flavonoids from *Erythrina latissima*. *Planta Med.* **68**, 640-642.

Watjen, W., Schnitker, A.K.S., Rohrig, R., Kulawik, A., Kyereme, J.A., Wright, C.W. and Passreiter, C.M. 2008. Prenylated flavonoids derivatives from the bark of *Erythrina addisoniae*. *J. Nat. Prod.* **71**, 735-738.

Xiaoli, L., Naili, W., Sau, W.M., Chen, A.S.C. and Xinsheng, Y. 2006. Four new isoflavonoids from the stem bark of *Erythrina variegata*. *Chem. Pharm. Bull.* **54**, 570-573.

Zheng, X., Wang, W., Piao, H., Xu, W., Shi, H. and Zhao, C. 2013. The genus *Gnaphalium* L. (Compositae): phytochemical and pharmacological characteristics. *Molecules* **18**, 8298-8318.

Zhou, J., Xie, G. and Yan, X. 2011. *Encyclopedia of Traditional Chinese Medicines.* Vol. **2**.