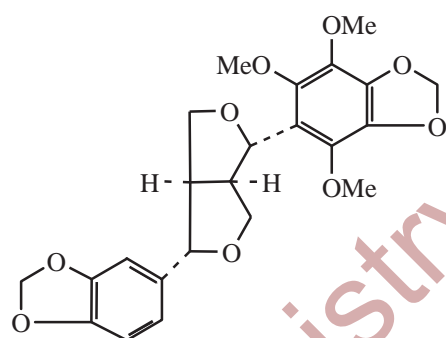


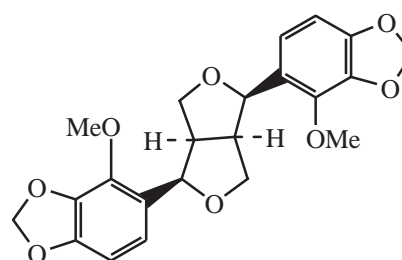
*Ecbolium viride* (a fodder plant in Oman) contains crude protein, 16.9; digestible organic matter, 66.3; neutral detergent fiber, 40.8; acid detergent fiber, 26.4 and P, 0.116% dry weight (Dickhoefer *et al.*, 2011).

Four flavonoids *viz.* orientin, isorientin, vitexin and isovitexin (in the ratio of 5:5:1:1) were isolated from the leaves, flowers and roots of *Ecbolium linnaeanum* (Nair *et al.*, 1975). Two furofuran type lignans have been identified from the roots of *Ecbolium linnaeanum* Kurz., growing in India, *viz.* ecbolin A (**97**) (Venkatarman and Gopalkrishnan, 2002a) and ecbolin B (**98**) (Venkatarman and Gopalkrishnan, 2002b). *p*-Hydroxybenzoic, vanillic, syringic and mellilotic acids were detected in *Ecbolium linnaeanum* (Daniel and Sabnis, 1987).

*Ecbolium linnaeanum* is reported to be useful in jaundice (Chopra *et al.*, 1956). The roots are also prescribed in jaundice and menorrhagia (Kirtikar and Basu, 1984). The roots and leaves are used against tumours. The ethanol extract (50%) of the plant is used in cardiovascular affections (Venkatarman and Gopalkrishnan, 2002a). Lalitha and Sethuraman (2010) reported that oral administration of *Ecbolium viride* extract reduced inflammation significantly ( $P < 0.01$ ) in both carageenan paw-edema and cotton pallet granuloma models. These results supported the traditional use of the plant in the treatment for inflammatory disease. In Saudi Arabia, leaves are used to treat pimples, and when applied around genital area it improves urination (Abulafatih, 1987).



97 Ecbolin A



98 Ecbolin B

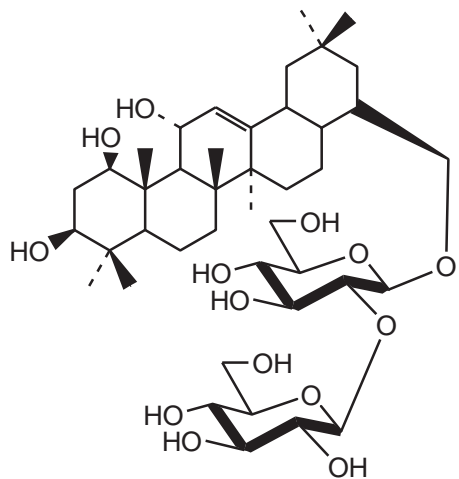
## 1.4. JUSTICIA L.

### Constituents

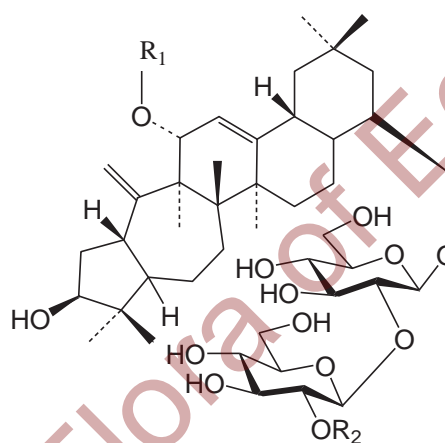
Analysis of the essential oil of *Justicia anselliana* (Nees) T. Anderson revealed the presence of  $\beta$ -phellandrene (51.2%), dihydrotageton (0.4%), propylbutyrate (0.3%) in the aerial parts and phenylacetaldehyde (39.2%),  $\delta$ -carene (31.7%), 6-methyl-5-hepten-2-one (16.4%) and  $\alpha$ -phellandrene (12.6%) in the roots (Kpoviessi *et al.*, 2009).

The aerial parts of *Justicia anselliana* contain  $\alpha$ -amyrin, lupeol, stigmaterol, campesterol and  $\beta$ -sitosterol (Kpoviessi *et al.*, 2008). Several triterpenoidal glycosides *viz.* justicisaponin-1 (Ghosal *et al.*, 1981), justiciosides A (**99**) - D (Kanchanapoom *et al.*, 2004c), E (**100**), F (**101**) and G (**102**) (Kanchanapoom *et al.*, 2005) were isolated from the aerial parts of *Justicia betonica* L. Lupeol and  $\beta$ -sitosterol 3-*O*-glucoside were identified from *Justicia simplex* (Sastry *et al.*, 1979).  $\beta$ -Sitosterol was identified in both *Justicia gendarussa* Burm. (Wahi *et al.*, 1974) and *Justicia aurea* (Srivastava and Bhadur, 2007).  $\beta$ -Sitosterol 3-*O*-glucoside, and a phytosterol fraction consisting of brassicasterol, campesterol, 7,22-ergostadienol,

stigmasterol, sitosterol, spinasterol and 28-isofucosterol were isolated from the aerial parts of *Justicia tranquebariensis* L. f. (Raju and Pillai, 1989). Investigation of the leaves, stems and roots of *Justicia flava* afforded a mixture of hydrocarbons,  $\beta$ -sitosterol- $\beta$ -D-glucoside, salicylic acid and a higher aliphatic alcohol having the hydrocarbon skeleton of squalene (Olaniyi, 1980). From the leaves of *Justicia spicigera*, a traditional Mexican plant, 3 $\beta$ -glucosyl-*O*-sitosterol, allantoin and cryptoxanthin were isolated (Dominiguez *et al.*, 1990).



99 Justicioside A



- 100 Justicioside E  $R_1, R_2=H$   
 101 Justicioside F  $R_1=H, R_2=\beta$ -D-GIC  
 102 Justicioside G  $R_1=Me, R_2=\beta$ -D-GIC

Lignans (arylnaphthalide, diarylbutane and  $\beta$ -apolignans) have been isolated from several *Justicia* species (Jyotishi and Bagavant, 1992; Mulabagal *et al.*, 2008). Examples of these lignans are shown in Table (7).

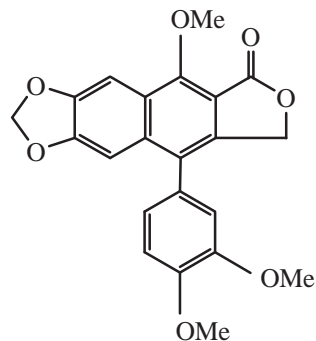
The aerial parts of *Justicia gendarussa* contain aromadendrin (dihydrokaempferol) (Bachheti *et al.*, 2011). *O*-Glycosides of quercetin and kaempferol were detected in the leaves of *Justicia pectoralis* Jacq. (Oliveria *et al.*, 2000). The leaves of *Justicia spicigera* yielded the bisrhamnoside of kaempferol and kaempferitrin along with a trace amount of kaempferol trirhamnoside (Euler and Alam, 1962; Dominiguez *et al.*, 1990). Kaempferol 7-methyl ether and vitexin 6-methyl ether were identified in *Justicia betonica* L. and *Justicia procumbens* var. *simplex* Yamazaki (Daniel and Sabnis, 1987).

Four *C*-glycosylflavones *viz.* swertisin, 2''-*O*-rhamnosylswertisin, swertiajaponin and 2''-*O*-rhamnosylswertiajaponin, were identified from *Justicia pectoralis* (Joseph *et al.*, 1988b; Joseph and Sainte-Luce, 1992). The flowers of *Justicia procumbens* var. *simplex* contain the anthocyanin peonidin 3-glucoside (Tiwari *et al.*, 1978). Several phenolic acids have been identified from *Justicia* species *viz.* vanillic, syringic and *p*-coumaric acids from *Justicia betonica* L.;  $\alpha$ -resorcylic, vanillic and syringic acids from *Justicia neesii* Ramam; *p*-hydroxybenzoic,  $\alpha$ -protocatechuic,  $\alpha$ -resorcylic, syringic, 3-hydroxy-4-methoxybenzoic and 3-hydroxy-5-methoxybenzoic acids from *Justicia procumbens* var. *simplex* Yamazaki; and *p*-hydroxybenzoic and vanillic acids from *Justicia trinervia* Vahl. (Daniel and Sabnis, 1987; De Vries *et al.*, 1988). Betaine, coumarin and umbelliferone were detected in *Justicia pectoralis* var. *stenophylla* (Macrae and Towers, 1984; De Vries *et al.*, 1988).

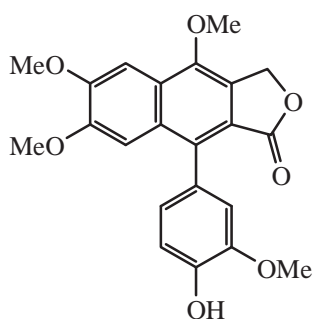
Betaine was also identified in *Justicia brandegeana* Wash. & Smith (Fischer *et al.*, 1988). Investigation of *Justicia pectoralis* Jacq. revealed the presence of coumarin, dihydrocoumarin, umbelliferone and 3-(2-hydroxyphenylpropionic acid) (De Vries *et al.*, 1988; Joseph and Sainte-Luce, 1992; Lino *et al.*, 1997). The study of the coumarin levels of *Justicia pectoralis* var. *stenophylla* Leonard, under different conditions was carried out by De

Barros *et al.* (1997). In red leaves, where carotenoids and anthocyanins are present, the amount of total coumarins was greater than in green leaves grown in sun or shade.

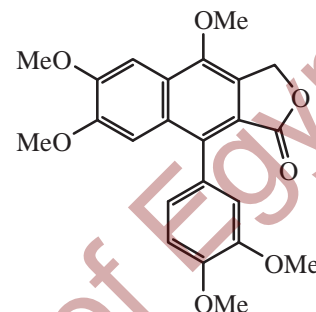
Naphthofurans, were isolated from *Justicia procumbens*. These compounds inhibit the absorption of calcium by bone (Soda *et al.*, 1992).



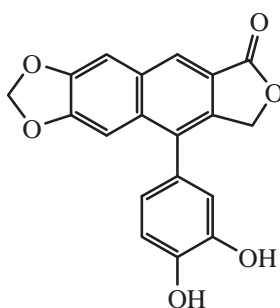
103 Justicidin A



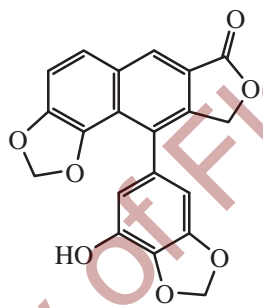
104 Cilinaphthalide A



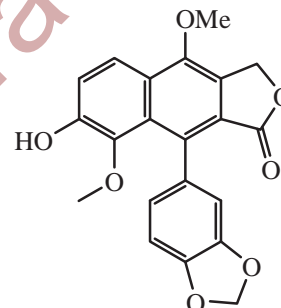
105 Cilinaphthalide B



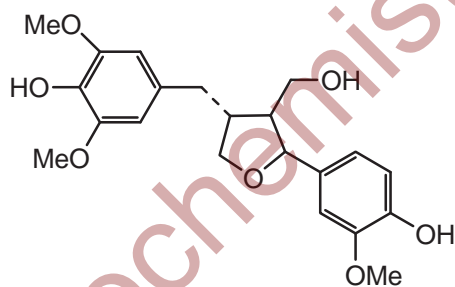
106 Prostalidin D



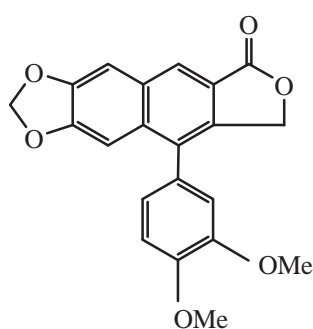
107 (+)-Isolariciresinol



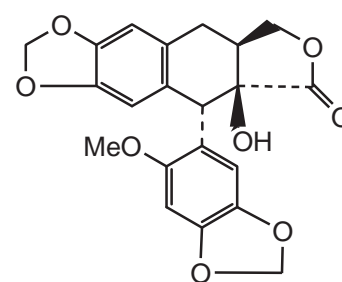
108 Orosunol



109 Justiciresinol



110 Justicidin B



111

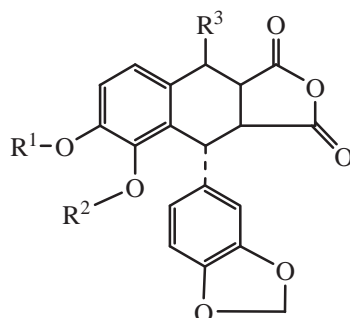
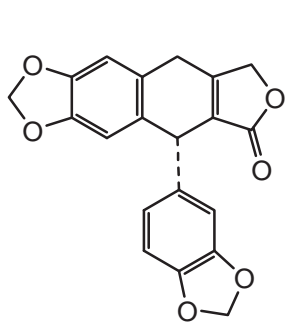
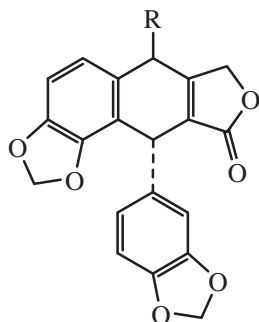
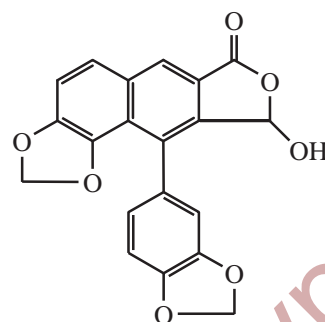
112 Justicidin J<sub>1</sub> R<sup>1</sup>=R<sup>2</sup>=OCH<sub>2</sub>O, R<sup>3</sup>=OMe113 Justicidin J<sub>2</sub> R<sup>1</sup>=R<sup>3</sup>=H, R<sup>2</sup>=β-D-glucose

Table 7 - Lignans of some *Justicia* species

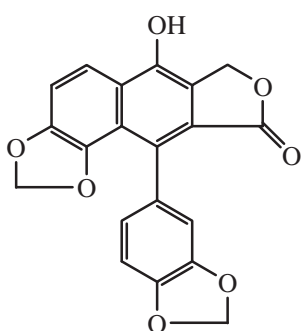
Species	Plant Part	Lignans	References
1- <i>Justicia ciliata</i>	Wp	Justicidin A ( <b>103</b> ), cilinaphthalide A ( <b>104</b> ), cilinaphthalide B ( <b>105</b> ), ciliatocide A and ciliatocide B	Day <i>et al.</i> (1999, 2000); Lu <i>et al.</i> (2008)
2- <i>Justicia diffusa</i>		Justicidin E, medioresinol dimethyl ether, pinoresinol, lariciresinol and isolariciresinol	Subbaraju and Pillai (1996)
3- <i>Justicia diffusa</i> var. <i>prostrata</i>		Justicidin A, justicidin E, helioxanthin, medioresinol, medioresinol dimethyl ether, lariciresinol, 8-methoxy-lariciresinol and prostalidin D ( <b>106</b> )	Rajasekhar <i>et al.</i> (2000)
4- <i>Justicia flava</i>	L	Helioxanthin, justicidin, and (+)- isolariciresinol ( <b>107</b> )	Olaniyi and Powell (1980)
	R	Orosinol ( <b>108</b> ), 8-demethylorosinol, isolariciresinol and 8-methoxyisolariciresinol	Olaniyi (1982)
5- <i>Justicia glauca</i>	Ap	Jusglaucinol, justiciresinol ( <b>109</b> ), lariciresinol, 5,5'-dimethoxy-lariciresinol, medioresinol and syringaresinol	Rajendiran <i>et al.</i> (1991) Subbaraju <i>et al.</i> (1991)
6- <i>Justicia hayatai</i>		Justicidin A ( <b>103</b> ), and justicidin B ( <b>110</b> )	Munakata <i>et al.</i> (1965)
7- <i>Justicia hayati</i> var. <i>decumbens</i>		Justicidin A and justicidin B	Munakata <i>et al.</i> (1965); Ohta <i>et al.</i> (1969)
8- <i>Justicia heterocarpa</i>	L	A podophyllotoxin lignan ( <b>111</b> )	Al- Juaid and Abdel- Mogib (2004)
9- <i>Jsticia hyssopifolia</i>		Cubebin, helioxanthin, gadain, justicidins E, J <sub>1</sub> ( <b>112</b> ), J <sub>2</sub> ( <b>113</b> ), elenoside, sesamin, and justicidone (a <i>p</i> -quinone lignan)	Trujillo <i>et al.</i> (1990); Navarro <i>et al.</i> (2004); Perez <i>et al.</i> (2004)
10- <i>Justicia laxa</i>		Laxanol	Hu <i>et al.</i> (2008)
11- <i>Justicia neesii</i> (syn. <i>Justicia micrantha</i> )		1, 4- Dihydrotaiwanin C ( <b>114</b> ), jusneesiin ( <b>115</b> ), jusneesiinol ( <b>116</b> ), jsmicranthin ( <b>117</b> ), justirumalin ( <b>118</b> ), helioxanthin, taiwanin C, retrohelioxanthin, justicidin A, justicidin G ( <b>119</b> ), tiruneesiin ( <b>120</b> ), jsmicranthin ethyl ether,	Rajasekhar <i>et al.</i> (1998, 1999); Rajasekhar and Subbaraju (2000); Gopaliah <i>et al.</i> (2001); Subbaraju



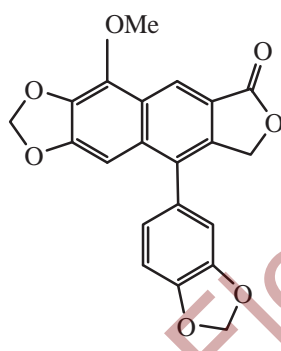
114 14-Dihydrotaiwanin C

115 Jusneesiin R=H  
116 Jusneesiinol R=βOH

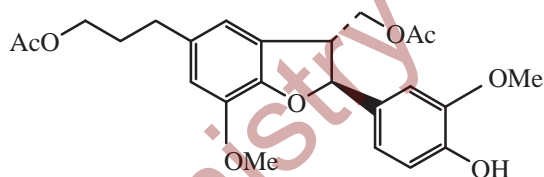
117 Jsmicranthin



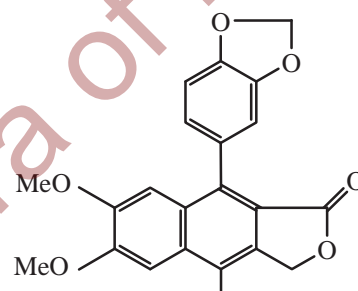
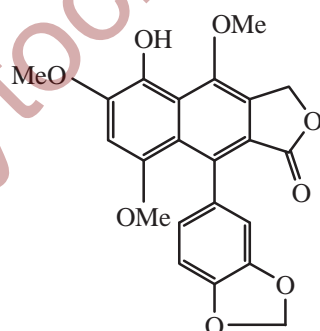
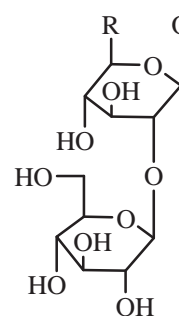
118 Justirumalin



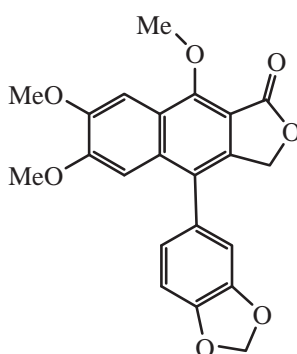
119 Justicidin G



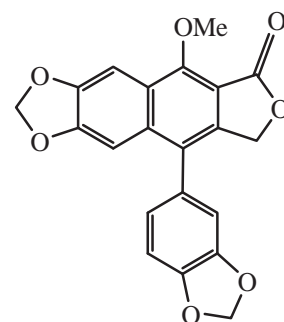
120 Tiruneesiin

121 Neesiin A R=H  
122 Neesiin B R=CH<sub>2</sub>OH

123 Justicinol



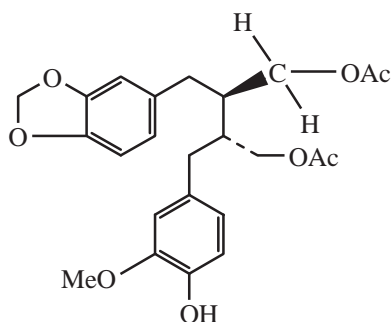
124 Justicidin C



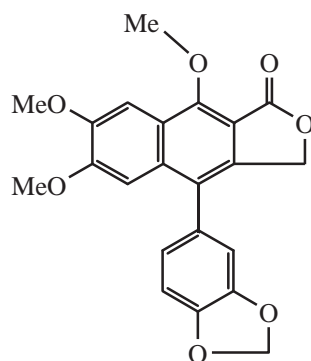
125 Justicidin D

Table 7 - Lignans of some *Justicia* species (cont.)

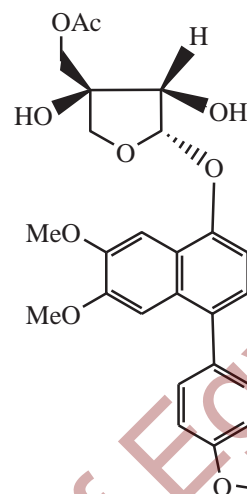
Species	Plant Part	Lignans	References
12- <i>Justicia orbiculata</i>		taiwanin E methyl ether, neesiinoside A ( <b>121</b> ), neesiinoside B ( <b>122</b> ), lignan J, jusicranthin methyl ether and jusneesiinol	<i>et al.</i> (2001); Mulabagal <i>et al.</i> (2008)
		Justicidin E, (+)- sesamolol, (-)-simplexolin, xanthoxylol and sesamin	Babu <i>et al.</i> (2001a); Mulabagal <i>et al.</i> (2008)
13- <i>Justicia patentiflora</i>	L,S	Justicinol ( <b>123</b> ), justiflorinol, patentiflorin A, patentiflorin B, 4"-O-acetylpatentiflorin A, 4"-O-acetylimanathoside B, diphyllin, justicidin A, taiwanin E, and tuberculatin	Susplugas <i>et al.</i> (2005)
14- <i>Justicia pectoralis</i>	Wp	Justicidin B	Joseph <i>et al.</i> (1988a)
15- <i>Justicia procumbens</i>	FP	Justicin, and isojusticin	Tsukamoto and Kishimoto (1955); Ohta and Munakata (1970)
	Wp	Diphyllin, justicidin A, Justicidin B, justicidin C ( <b>124</b> ), justicidin D ( <b>125</b> ), justin A ( <b>126</b> ), neojusticin A, neojusticin B ( <b>127</b> ), justin B, justin C, dihydroclusin diacetate, secoisolariciresinol dimethyl ether diacetate, 5- methoxy 4,4-di-O-methylseclaricresinol diacetate, 2,3- dimethoxysecoisolintetralin acetate, secoisolariciresinol dimethyl ether, 5- methoxy-4,4- di-O-methylseclaricresinol, diphyllin apioside-5- acetate ( <b>128</b> ), justicidin A, justicidin B, justicidin C, taiwanin E methyl ether, cihinensinaphthol, 4'-demethylchinensinaphthol methyl ether, cilinaphthalide B, procumphthalide A and procumphthalide B, procumbenoside A ( <b>129</b> ), neojusticin C, procumbenoside C, procumbenoside D, chinensinaphthol methyl ether, isodiphyllin, taiwanin C, 6'-hydroxyjusticidin A, 6'-hydroxyjusticidin B, 6'- hydroxyjusticidin C and tuberculatin	Jin <i>et al.</i> (1982); Fukamiya and Lee (1986); Asano <i>et al.</i> (1996); Chen <i>et al.</i> (1996,1998a); Day <i>et al.</i> (2002); Weng <i>et al.</i> (2004); Yang <i>et al.</i> (2006); Guorui <i>et al.</i> (2008); Liu <i>et al.</i> (2008); Lu <i>et al.</i> (2008)



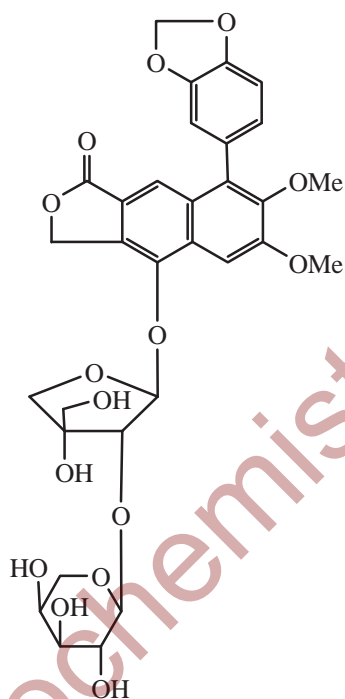
126 Justin A



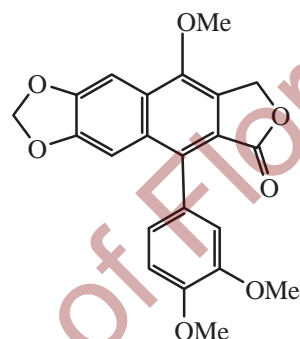
127 Neojustin B



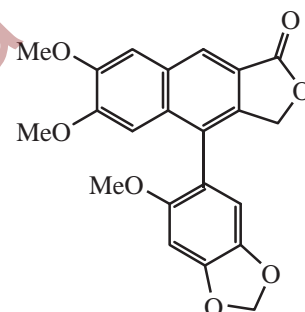
128 Diphyllin apioside 5-acetate



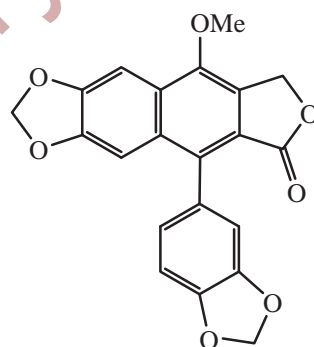
129 Procumbenside A



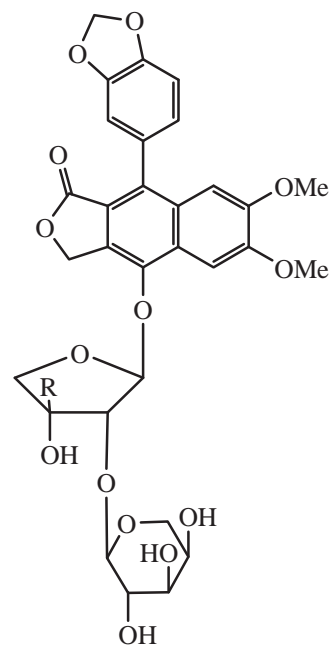
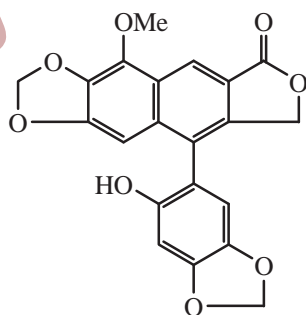
130 Chinensinaphthol methyl Ether



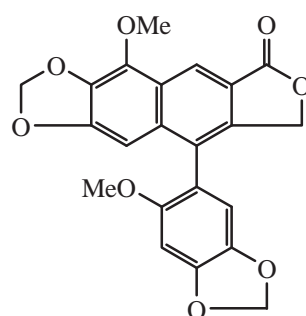
131 Procumpthalide A



132 Taiwanin E methyl ether

133 Ciliatocide A  
R=CH<sub>2</sub>-O-β-D-xylopyranosyl

134 Prostalidin A



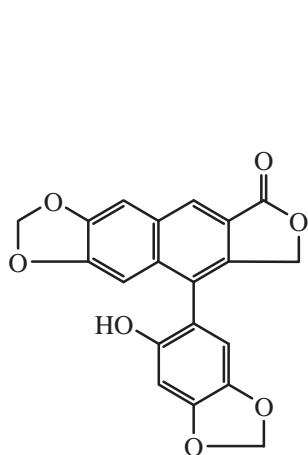
135 Prostalidin B

Table 7 - Lignans of some *Justicia* species (cont.)

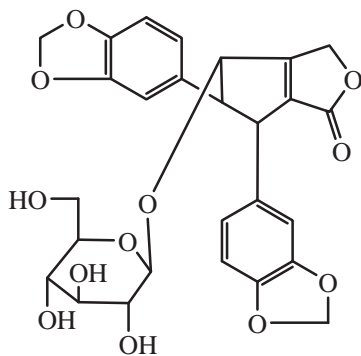
Species	Plant Part	Lignans	References
16- <i>Justicia procumbens</i> var. <i>hayatai</i>	Hp	Diphyllin, justicidin A, justicidin B, justicidin C, justicidin D, justicidin E, chinensinaphthol methyl ether (130), procumpphthalide A (131), taiwanin E methyl ether (132), and ciliatocide A (133)	Wu <i>et al.</i> (2007)
17- <i>Justicia prostrata</i>		Prostalidin A (134), prostalidin B (135), prostalidin C (136), retrochinensin, procumpphthalide-A, cilinaphthalide-A, justicidin B and 4- <i>O</i> - $\beta$ -D-apiofuranosyl-(1'' $\rightarrow$ 6'')- $\beta$ -D-glucopyranosyldiphyllin	Ghosal and Banerjee (1979); Ghosal <i>et al.</i> (1979b); Pandey <i>et al.</i> (2011)
18- <i>Justicia purpurea</i>	Wp	Juspurpurin (137), justalakomin (138)	Kavitha <i>et al.</i> (2003); Mulabagal <i>et al.</i> (2008)
19- <i>Justicia simplex</i>	Wp	Helioxanthin, justicidin C (neojusticidin B), justicidin E, justisolin (139), simplexoside (140), simplexolin (141), sesamin, asarinin and sesamol	Sastry <i>et al.</i> (1979); Ghosal <i>et al.</i> (1979a, 1980)
20- <i>Justicia tranquebariensis</i>	Ap	Lariciresinol (142), isolariciresinol (143), lyoniresinol (144), medioresinol (145) and 8- methoxyisolariciresinol (146)	Raju and Pillai (1989); Mulabagal <i>et al.</i> (2008)

Ap: aerial parts, Fp: flowering plant, L: leaves, R: roots, S: seeds, Wp: whole plant

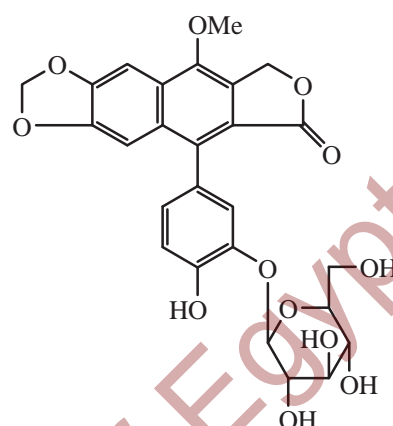




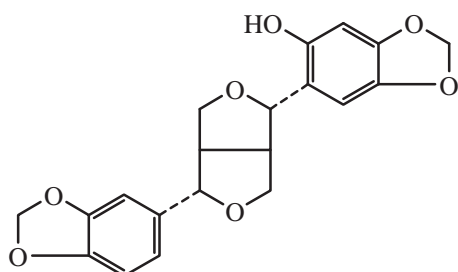
136 Prostalidin C



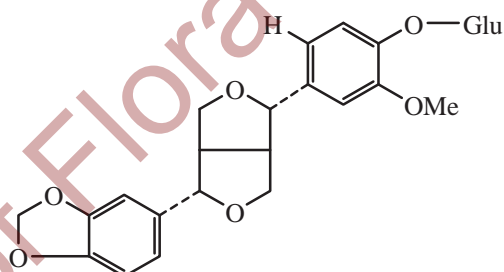
137 Juspurpurin



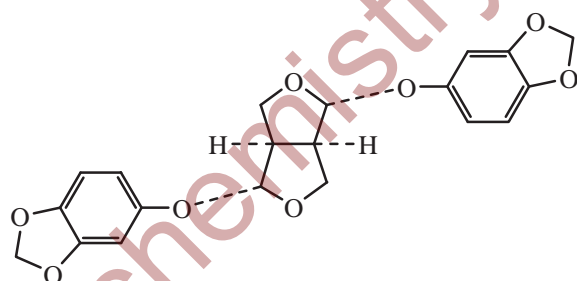
138 justalakonin



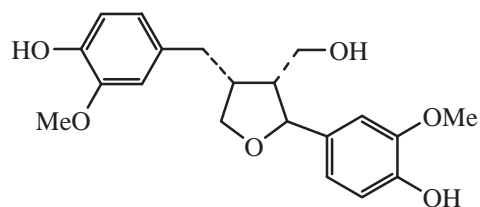
139 Justisolin



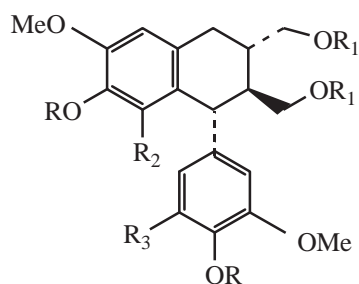
140 Simplexoside



141 Simplexolin



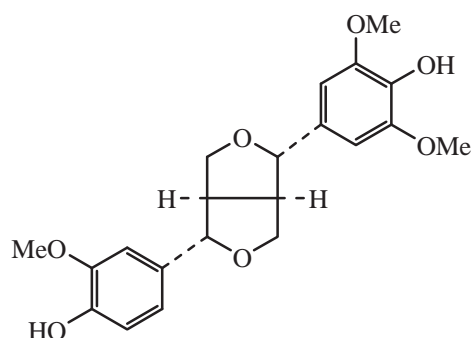
142 (+)-Lariciresinol



143 (+)Isolariciresinol

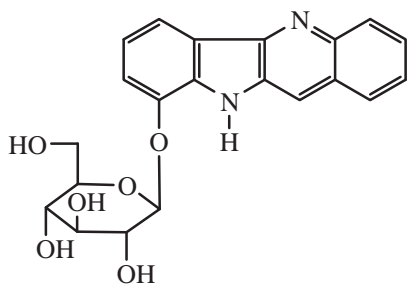
144 (+)Lyoniresinol

146 (+)-8-Methoxyisolariciresinol

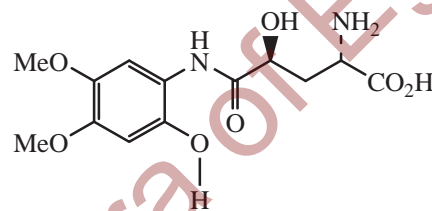
R=R<sub>1</sub>=R<sub>2</sub>=R<sub>3</sub>=HR=R<sub>1</sub>=COCH<sub>3</sub>; R<sub>2</sub>=R<sub>3</sub>=OCH<sub>3</sub>R=R<sub>1</sub>=R<sub>3</sub>=H; R<sub>2</sub>=OCH<sub>3</sub>

145 (+)-Medioresinol

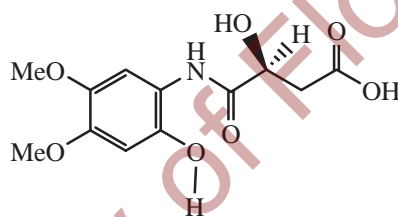
Jusbetonine (**147**) (an indole [3,2-*b*] quinoline alkaloid glycoside), 10-*H*-quinoline, 6-*H*-quinindoline and 5*H*,6-*H*-quinindolin-11-one have been isolated from the leaves of *Justicia betonica* (Subbaraju *et al.*, 2004). Chakravarty *et al.* (1982) isolated four simple aromatic amines from the leaves of *Justicia gendarussa* viz. 2-H<sub>2</sub>NC<sub>6</sub>H<sub>4</sub>CH<sub>2</sub>OR (I, R=H; II, R=Me) and 2-RCH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>NHCH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>NH<sub>2</sub> (III, R=H; IV, R=Me). Justiciamide (**148**), an amide of L-threo- $\gamma$ -hydroxyglutamic acid was isolated from *Justicia ghiesbreghtiana* (Lorenz *et al.*, 1999). The leaves of the latter species yielded *N*-(2-hydroxyl-4,5-dimethoxyphenyl)-(*S*)- $\alpha$ -malamic acid (**149**) (Ismail *et al.*, 1998).



147 Jusbetonine



148 Justiciamide



149

### Folk Medicine, Pharmacological and Biological Activities

The aerial parts of *Justicia betonica* L. are used in Indian traditional medicine as an anti-diarrhea medicine, as well as anti-inflammatory agent (Kanchanapoom *et al.*, 2004c).

The leaf of *Justicia euosmia* Lindau is made by the Bugu into an ointment with butter for application to pimples and pustules. A decoction of the root of *Justicia matammensis* Oliv. is a Bondei remedy for inflammation of the testicles. The leaf and root of the plant are Shambala remedies for heart diseases (Watt and Breyer-Branjdwijk, 1962).

The roots of *Justicia gendarussa* have been early reported to produce a slight pyresis, and was depressing with an accompanying antipyretic effect in doses of 10-20 gm/kg producing a violent diarrhea and eventually death (Hutchins and Smith, 1937).

The brine shrimp toxicity by *Justicia graciflora* (Gupta *et al.*, 1996b) and the 10*H*-indolo[3,2-*b*] quinoline isolated from *Justicia betonica* (Arunakumari *et al.*, 2007) has been reported. Mruthunjaya and Hukkeri (2007) stated that the leaves of *Justicia gendarussa* Burm. possess antioxidant activity and the flavonoids are responsible for this activity. Prostalidin A, a lignan isolated from *Justicia prostrata* produced mild antidepressant activity in albino mice and rats (Ghosal *et al.*, 1979). The ethanolic extract of *Justicia neesii* Ramamoorthy, exhibited anticancer activity against P388 lymphocytic leukaemia in mice (Aswal *et al.*, 1984).

*Justicia gendarussa* is useful in bronchitis, inflammations, vaginal discharges, dyspepsia, tympanitis, eye diseases and fevers. The leaves and tender shoots are diaphoretic and are given in chronic rheumatism in the form of decoction. An oil prepared from the leaves when applied locally is said to be useful in eczema, and an infusion of the leaves is given internally