

Review Article

Phytochemicals and antimicrobial potentials of mahogany family



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ABSTRACT

Drug resistance to human infectious diseases caused by pathogens lead to premature deaths throughout the world. Plants are sources for wide variety of drugs used for treating various diseases. Systematic screening of medicinal plants for the search of new antimicrobial drug candidates that can inhibit the growth of pathogens or kill with no toxicity to host is being continued by many laboratories. Here we review the phytochemical investigations and biological activities of Meliaceae. The mahogany (Meliaceae) is family of timber trees with rich source for limonoids. So far, amongst the different members of Meliaceae, *Azadirachta indica* and *Melia dubia* have been identified as the potential plant systems possessing a vast array of biologically active compounds which are chemically diverse and structurally complex. Despite biological activities on different taxa of Meliaceae have been carried out, the information of antibacterial and antifungal activity is a meager with exception to *Azadirachta indica*. Together we provide new insights of Meliaceae members demonstrating as a potential source as antimicrobial agents using *in vitro* studies.

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Introduction

World wide, infectious disease is the number one cause of death accounting for approximately one-half of all deaths in tropical countries. Plants constitute one of the major raw materials of drugs for treating various human diseases. The modern society has been interested in drugs of natural origin due to their harmonious nature with our biological system (Amalraj, 1983). It is reported that 41% prescriptions in USA and 50% in Europe contain constituents from natural products which shows that the trend of using natural products is getting increased. Scientific research on medicinal plants relies on identification of the active principles in the plants; scientific examination of the remedies which lead to standardization and quality control of products to ensure their safety. It is after such evaluations that they can be approved for use in the primary health care. Such research

activities could also lead to the development of new drugs as in the past (Farnsworth et al., 1985; Farnsworth, 1988). Phytochemical tests have been performed in about 5000 species and nearly 1100 species are extensively exploited in Ayurvedic, Unani and Allopathic medicines. In fact active plant extracts screening programs continue to end always with new drug discoveries.

In order to find new sources of plant drugs, number of plants has been screened for wide range of biological activity in various research institutions. Plant based antimicrobials represent a vast untapped source for medicines by possessing enormous therapeutic potential. They are effective in the treatment of infectious diseases while simultaneously mitigating many of the side effects that are often associated with synthetic antimicrobials. Although, a number of antibiotics are widely used in medicine, the search for antimicrobial substances from plants will continue as better and safer drugs to combat bacterial and fungal infections are still needed, because of their biodegradable nature and being relatively safer for human beings and non-target organisms in the environment. Extensive survey of the flora has been undertaken to search for potential plant extracts, which could

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be used in the management of agriculture and household pests. In order to study possible applications of extracts or compounds derived from extracts, methods to screen for biological activities and separation techniques to isolate the active principles have to be established. Nearly 80% of the world's population relies on traditional medicines for primary health care, most of which involve the use of plant extracts (Sandhya et al., 2006). Almost 95% of the prescriptions are plant based in the traditional systems of Unani, Ayurveda, Homoeopathy and Siddha (Satyavati et al., 1987).

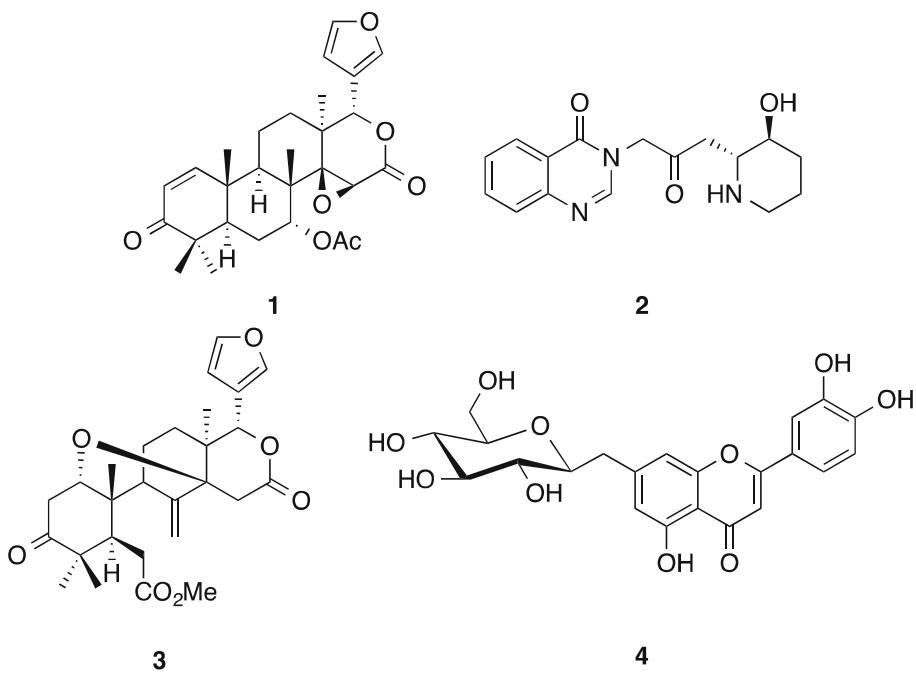
The mahogany (Meliaceae) family comprises more than fifty genera with about 1400 species (Nakatani et al., 2001) is distributed in tropical and subtropical regions. The family is represented by seventeen genera and 72 species of which twelve species and two varieties endemic in India. Approximately 18% are endemic to peninsular India. From 19th century up to the present time, the mahoganies have been the most important species for the development of the forest industry in Asia, tropical Africa and Latin America. Many species of this family were used in traditional medicine for treatment of various diseases and also in pest control. Here we review the phytochemical investigations and biological activities of Meliaceae. Together we provide insights of Meliaceae members demonstrating as a potential source as antimicrobial agents using *in vitro* studies. Till to date there is no review published on the phytochemical constituents and their antimicrobial properties of Meliaceae. Hence our review aims to coherently unite results obtained from various published investigations on this important family. Here we address the important phytochemical constituents of Meliaceae and plants that have been investigated for their antimicrobial potential other than *A. indica* from Meliaceae.

Phytochemical studies of Meliaceae

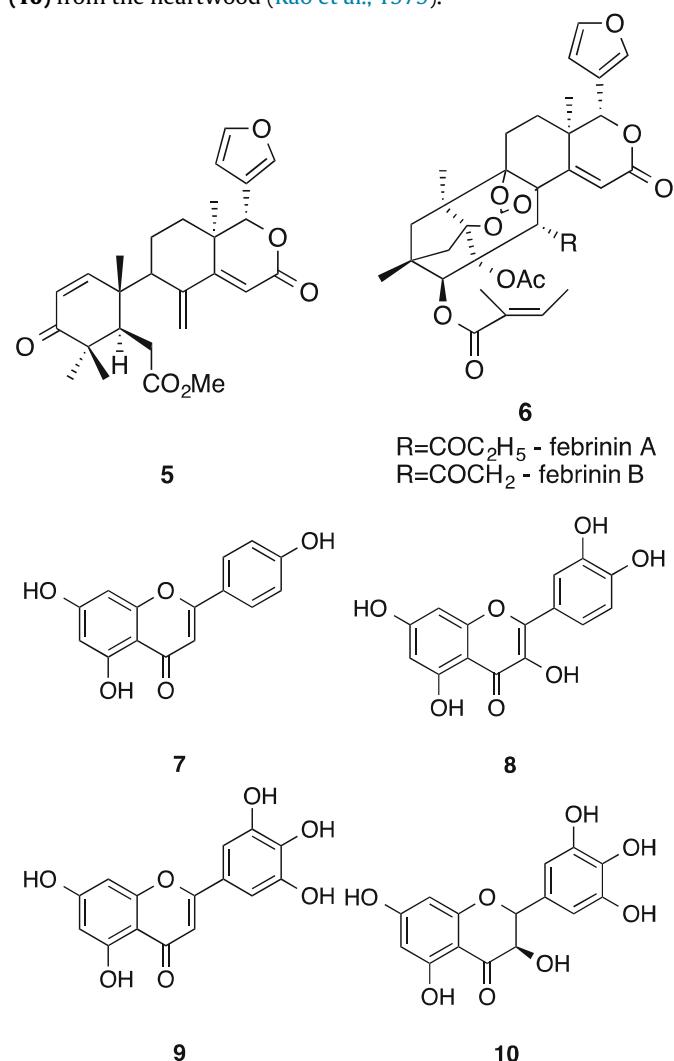
Various classes of chemical constituents were isolated from different parts of meliaceous members. Chemically, the Meliaceae

is characterized by synthesis of modified triterpenes known as limonoids. Over 300 limonoids have been isolated to date and they are more diverse and abundant in this particular family than in any other family. Several triterpenoidal derivatives were also isolated from different genera of Meliaceae. Amongst different members of Meliaceae, *Azadirachta indica* had been extensively studied for its chemicals. Limonoids are secondary metabolites produced in plants found in the order Rutales. Over 300 limonoids have been isolated to date (Taylor, 1986; Champagne et al., 1992) and their production is confined to plants in the order Rutales. In particular, they are characteristic members of the family Meliaceae where they are diverse and abundant (Taylor, 1981; Connolly, 1983) than in any other family and less frequently in the families Rutaceae and Cneoraceae.

Limonoids are described as modified triterpenes, having a 4,4,8-trimethyl-17-furanyl steroid skeleton. The term limonoids was derived from limonin, the first tetranortriterpenoid obtained from citrus bitter principles (Roy and Saraf, 2006). The effect of ring structure and chemical oxidation state parameters is a focus of why limonoids exhibit activity against insect herbivores. Arrangements of subgroups and ring structures within this basic building block provide a host of characteristics that have generated interest in this plant product. These characteristics include insecticidal, insect growth regulation, insect antifeedant, and medicinal effects to animals and humans such as antibacterial, viral, and antifungal properties. Of recent great interest, limonoid's possible anticarcinogenic properties are being explored. Of special interest to countries in tropical locations is the antimalarial activity attributed to tropical Meliaceae extracts and gendunin (**1**) derivatives. Previous investigations from various plant parts of Meliaceae led to the isolation of tetranortriterpenoids with a modified furan ring such as febrifugin (**2**) (Rao et al., 1978) methyl angolensate (**3**), luteolin-7-O-glucoside (**4**), deoxyandirobin (**5**) from the bark (Ambaye et al., 1971; Adesida and Taylor, 1972; Purushothaman and Chandrasekharan, 1974; Purushothaman et al., 1977).



Tetranortriterpenoids febrifugin (**2**) (Rao et al., 1978) and febrinins A and B (**6**) (Rao et al., 1979) together with the flavonoids naringenin (**7**), quercetin (**8**), myricetin (**9**) and dihydromyricetin (**10**) from the heartwood (Rao et al., 1979).



Seed oil containing linolenic, linoleic, oleic, palmitic and stearic acid, lupeol and sitosterol (Yoganarasimhan, 1996). Leaves were found to contain quercetin-3-O-β-D-rhamnoside and 3-O-rutinoside (Rastogi and Mehrotra, 1993).

In view of the characteristic occurrence of the gedunin nucleus in the Meliaceae, the name meliacin has been proposed for this nucleus (Bevan et al., 1963). Compounds which may arise from closely similar biogenetic routes have also been isolated from the related families Rutaceae and Simarubaceae (Arigoni et al., 1960; Narayanan et al., 1964). It has been proposed that the Meliaceae compounds are derived biogenetically from an apo-euphol type triterpene in which the side chain has been oxidized leaving a furan ring (Arigoni et al., 1960). Possessing a reduced furan ring, flindissol is structurally midway between epo-euphol and the meliacins, and indicates a biochemical relationship between the two families. This inference is strengthened by the occurrence of a coumarin, a characteristic of the Rutaceae, in *Ekbergia senegalensis* (Meliaceae). It is hoped that elucidation of the structures of the other meliacins will reveal features giving more information about the biochemical relationships of these compounds, as well as making available further taxonomic criteria in this important family.

Various classes of chemical constituents were isolated from different parts of meliaceous members (Box 1). Amongst the

different members of Meliaceae, *Azadirachta indica* and *Melia dubia* have been identified as the potential plant systems possessing a vast array of biologically active compounds, which are chemically diverse and structurally complex. It seems that other members of this family are tested for secondary metabolites and bioactivity besides multiplication, overcoming physiological barriers.

Antimicrobial activity of Meliaceae

One of the major triumphs of medical science in the millennium has been the virtual eradication of many infectious diseases by the use of specific antimicrobial agents. Two important discoveries marked the beginning of a new era in chemotherapy. First discovery in 1935 curative discovery and development of the sulfonamide on *Streptococcal* infection. Second important pharmacokinetic property of the antibiotics quite varied, as are their antimicrobial spectra and mechanisms of action. Although, a number of antibiotics are widely used in medicine, the search for antimicrobial substances from plants will continue as better and safer drugs to combat bacterial and fungal infections are still needed, because of their biodegradable nature and being relatively safer for human beings and non target organisms in the environment. Plant extracts that inhibit pathogenic microorganisms without harming the host may have potential use as therapeutic agents. The susceptibility of a microorganism to antibiotics and other chemotherapeutic agents can be determined by the different methods available like tube-dilution, Paper-disk-plate, cylinder and well methods, single disk method and agar overlay method. The screening of large numbers of bacteria and fungi with various antibiotics and synthesized drugs requires simple techniques that can be used with several samples at the same time. Disk diffusion method for susceptibility testing currently recommended by the FDA is a slight modification of the procedure developed by Bauer et al. (1966). Different parts of meliaceous members were screened for the antibacterial and antifungal activity (Box 2).

Ethyl acetate extracts of *Chukrasia tabularis* leaves inhibited the growth of microorganisms like *Staphylococcus aureus*, *Escherichia coli*, *Proteus vulgaris*, *Klebsiella pneumoniae*, *Aspergillus fumigatus* and *Pseudomonas aeruginosa* (Nagalakshmi et al., 2001). Jayasinghe et al. (2002) screened the antimicrobial activity of two Meliaceae members like *Agalia congylos* and *Munronia pumila*. According to them the methanol, n-hexane and dichloromethane extracts of leaves, bark and stem displayed the wide spectrum of antimicrobial activity against *Aspergillus*, *Saccharomyces*, *Ustilago*, *Escherichia*, *Micrococcus* and *Bacillus* species. Antibacterial activity of methanol and acetone flower extracts of *Azadirachta indica* by disk assay on most sensitive organisms like *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli*, *Bacillus cereus* and *Salmonella infantis* were tested by Alzoreky and Nakahara (2003). Aladesanmi and Odediran (2000) stated that *Trichilia heudelotti* leaves can be regarded as having moderate antibacterial and antifungal activities determined by the cup plate method using n-hexane, ethyl acetate, methanol extracts and some isolated compounds. Chowdhury et al. (2003a) reported that petrol ether, dichloromethanol and methanol extracts along with siderin of two Meliaceae medicinal plants, *Toona ciliata* and *Amoora rohituka* (stem bark) exhibited significant antibacterial activity and mild antifungal effect.

Although several aspects of biological activity on different taxa of Meliaceae have been carried out, the information of antibacterial and antifungal activity is a meager excepting that of *Azadirachta indica*. Samy and Ignacimuthu (1998) reported that when antibacterial activity of different crude extracts of seed kernel, seed coat and leaves of *Azadirachta indica* were tested against *Escherichia coli*, *Pseudomonas aerogenes*, *Klebsiella aerogenes* and *Proteus vulgaris*, only the seed kernel extracts was found to show significant

Box 1: Phytochemical investigations of Meliaceae.

Plant	Part used	Compound	Reference
<i>Aglaia andamanica</i>	Leaves	Limonoid 24- <i>epi</i> -mellanodiol, the tirucallane aglaidiol and the two cyclopenta tetra hydrobenzo pyran derivatives pyramidaglan A and B	Puripattanavong et al., 2000
<i>Aglaia argentea</i>	Leaves	Cycloartanes, argenteanones C-E and genteanols B-E	Mohammad et al., 1997
		Cycloartanes: argenteanones A and B, and argenteanol	Omobuwajo et al., 1996
	Bark	3,4-Seco apo tirucallanes, argentinic acids A-I	Mohamad et al., 1999a
	Seeds	Apotirucallane triterpenes-gentinones A-D and gentinin	Omobuwajo et al., 1996
<i>Aglaia cordata</i>	Stem bark	Aglacins I-K three highly methoxylated lignans	Wang et al., 2004a
<i>Aglaia crassinervia</i>	Bark	Glabretal-type triterpenoids, aglaiglabretols A-C, nine known compounds, 3- <i>epi</i> -cabraleahydroxylactone, cabraleahydroxylactone, rocaglaol, 2β,3β-dihydroxy-5α-pregn-17(20)-(E)-16-one, scopoletin, mixtures of cabraleadiol, epicotillol, β-sitosterol and stigmasterol	Su et al., 2006
<i>Aglaia dasyclada</i>	Leaves	Rocaglamides, glycosides and putrescine bisamides	Chaidir et al., 2001
<i>Aglaia duperreana</i>	Twigs and leaves	Rocaglamide derivatives and rocaglamides	Nugroho et al., 1997a
<i>Aglaia edulis</i>	Flowers	Insecticidal cyclopenta tetra hydro benzofuran derivatives of rocaglamide	Chaidir et al., 1999
	Leaves	A bisamide, aglaiduline, and sulfur-containing bisamides, aglaithioduline and aglaidithioduline	Saifah et al., 1999
	Bark	Benzob[<i>b</i>]oxepine derivatives, edulisones A and B	Kim et al., 2005
		Cyclopental[<i>b</i>]benzofurans, aglaroxin A 1-O-acetate and 3'-methoxyaglaroxin A 1-O-acetate, benzo[<i>b</i>]oxepine, 19,20-dehydroedulisone A, and cyclopental[<i>bc</i>]benzopyrans, edulirin A, edulirin A 10-O-acetate, 19,20-dehydroedulirin A, isoedulirin A, and isoedulirin B, cyclopental[<i>b</i>]benzofuran, aglaroxin A	Kim et al., 2006
	Roots	Favaglines, cyclopental[<i>bc</i>]benzopyrans (thapsakins) and benzo[<i>b</i>]oxepines (thapoxepines), together with two known cyclopental[<i>b</i>]benzofurans, aglaroxin A and pannellin	Bacher et al., 1999
<i>Aglaia elaeagnoides</i>	Bark	Lignans <i>trans</i> -2,3-bis(3,4,5-trimethoxybenzyl)-1,4-butanediol diacetate and 20S,24S-epoxy-25-hydroxymethyldammarane-3-one, one 1H-cyclopentatetrahydro[<i>b</i>]benzofuran, two dammarane triterpenoids and one limonoid	Fuzzati et al., 1996
<i>Aglaia elliptica</i>	Fruits	Rocaglamide derivatives along with rocaglamide and didesmethylrocaglamide	Nugroho et al., 1997b
<i>Aglaia exima</i>	Leaves	Cycloartane; 24(E)-cycloart-24-ene-26-ol-3-one, cycloartane-type triterpenoids 24(E)-cycloart-24-ene-26-ol-3-one, cycloart-24-ene-3β,26-diol, schizandronic acid, 24(E)-3β-hydroxycycloart-24-ene-26-al, vaticinone, one dammarane-type triterpenoids cabraleahydroxylactone, and two steroids; β-sitosterol and stigmast-5-ene-28-one	Awang et al., 2012
	Stem bark	Stigmastane steroid, 3,4-epoxy-(22R,25)-tetrahydrofuran-stigmast-5-en, triterpenoids dammara-20,25-diene-3b,24-diol, dammara-20S, 5a,24-en,3b,20-diol and steroids stigmasterol 3-O-β-d-glucoside and stigmast-5-ene-3b,4b-diol	Harneti et al., 2014
<i>Aglaia foveolata</i>	Leaves	Flavagline derivatives: foveoglin A, foveoglin B, isofoveoglin, cyclofoveoglin, secofoveoglin and silvestrol, pyramidatine	Salim et al., 2007a
	Stem bark	Baccharane-type triterpenoid and silvestrol, 17,24-epoxy-25-hydroxy-3-oxobaccharan-21-oic acid	Roux et al., 1998
		Dammarane triterpenes, foveolins A and B, together with three known, 3- <i>epi</i> -ocotillol, eichlerianic acid and shoreic acid	
<i>Aglaia gracilis</i>	Leaf	Secopiriferine and secodoridine and known compounds flavonol, flavagline, odorine, piriferine, pyramidatine, nosesquiterpene, desacetylglain A, aglaistatin,	Grege et al., 2001
	Root bark	Marikarin and 3'-hydroxy-marikarin along with known algafoline, aglaistatin, dehydroalgastatin, shoreic acid	Grege et al., 2001
<i>Aglaia grandis</i>	Leaves	Pregnanes and cycloartane type triterpenoid hydroperoxides Putrescine bisamides grandiamides A-C and aromadendrane-type sesquiterpene 4b,10a-dihydroxyaroma-	Inada et al., 1997
		Dendrane	Inada et al., 2000
<i>Aglaia harmsiana</i>	Leaves	Cycloartane type triterpene-Cycloartane-3β,29-diol-24-one, (24R)-cycloartane-24,25-diol-3-one	Inada et al., 1995
		Rocaglamide compound	
<i>Aglaia ignea</i>	Bark	Dammarenolic acid	Nugroho et al., 1997b
<i>Aglaia lawii</i>	Leaves	Dammaranes, aglinins A and B together with cabraleone, eichlerianic acid and shoreic acid	Esimone et al., 2010
	Bark	A pregnane steroid, namely (E)-aglawone 20S, 24S-epoxy-dammarane-3α,25-diol acetate	Mohamad et al., 1999a
		(+)-ocillatone, (+)-ocotillol, (+)-cabraleone, (+)-eichlerianic acid, (+)-caryophyllene oxide, (24Z)-3,4-secotirucalla-4 (28) 7,24-triene-3,26-dioic acid and 3-monomethyl ester.	Qiu et al., 2001
<i>Aglaia leucophylla</i>	Stem bark	Tirucallane triterpene, (−)-leucophyllone along with (−)-caryophyllene oxide, (−)-niloticin, (−)-bourjotinolone and (−)-piscidinol.	Benosman et al., 1994
			Benosman et al., 1995

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Aglaia loheri</i>	Leaves	Spinasterol, trilinolein, phytol fatty acid ester	Ragasa et al., 2012
<i>Aglaia odorata</i>	Leaves	Cyclopenta tetra hydro benzo furans along with desmethyl rocaglamide, methyl rocaglate, rocaglaol Odorine, odorinol and dehydrodorin Rocaglamide congeners, aglaine derivatives, two aminopyrrolidines odorine and odorinol, three flavonoid derivatives and syringaresinol	Ishibashi et al., 1993 Duh et al., 1993 Nugroho et al., 1999
		Dolabellane diterpenoids (1R,3E,7E,10S,11S,12R)-dolabella-3,7-dien-10,18-diol, (1R,3S,7E,11S,12R)-dolabella-4(16),7-dien-3,18-diol, (1R,7E,11S,12R)-18-hydroxydolabella-4(16),7-dien-3-one, (1R,3S,4S,7E,11S,12R)-3,4epoxydolabella-7-en-18-ol, and (1R,3R,7E,11S,12R)-dolabella-4(16),7,18-trien-3-ol.	Cai et al., 2010
	Leaves twigs	Dolabellane diterpenoids, two dammarane triterpenoids and a protostane triterpenoid Coumarinolignoid, 8-(70,80,90-propanetriol-40-methoxy-30-O-phenylpropanoid)-7-hydroxy-6-methoxycoumarin.	Yodsaue et al., 2012 Zhang et al., 2012a
	Twigs	Insecticidal rocaglamide compounds	Nugroho et al., 1999 Liu et al., 2014
	Dried twigs	Norsesquiterpene 4 α , 10 β -dihydroxy-1 β H,5 α H-guai-6(7)-en-11-one and four new sesquiterpenes 1 β ,4 α ,7 β -trihydroxy-14 β -methyl-eudesman-11(12)-ene, 1 α ,6 β ,12-trihydroxy-1 β H,5 α H,11H-guai-6(7)-ene, 4 α 7 β ,11-trihydroxy-1 β H,5 α H-guai-10(14)-ene, and 4 α ,10 α ,11-trihydroxy-1 β H,5 β H-guai-7(8)-ene along with four known guianediol, orientalol A, orientalol B and 1 β ,6 α -dihydroxy-10 β -methyl-5 α H,7 α H-eudesm-4-one	Janprasert et al., 1993
	Flower essential oil	Dammarane triterpenes and aminopyrrolidine bis-amides such as odorinol	Weyerstahl et al., 1999
<i>Aglaia oligophylla</i>	Leaves	Dipterocarpol, ocotillone, cabraleone, ocoottillol, 20(S),24(S)-dihydroxydammar-25-en-3-one, 20S,25-epoxy-24R-hydroxy-3-dammaranone, 20S,25-epoxy-24R-hydroxydammarane-3 α -ol, flavagaline rocaglaol, bisamides odorine and 20- <i>epi</i> -odorine	Joycharat et al., 2008
<i>Aglaia ponapensis</i>	Leaves and stems	Cyclopental[bc]benzopyran, ponapensin, and an aglaiolactone, 5,6-desmethylenedioxy-5-methoxy-aglaiolactone, cyclopental[b]benzofuran(methyl rocaglate) four cyclopental[bc]benzopyrans 4- <i>epi</i> -aglaine A, aglaine B, 10- <i>O</i> -Acetyl aglaine B, and aglaine C, and four pregnane steroids (E)-vulkendousin, (Z)-vulkendousin, 2 β ,3 β -dihydroxy-5-pregn-17(20)-(E)-en-16-one, 20 and 2 β ,3 β -dihydroxy-5-pregn-17(20)-(Z)-en-16-one	Salim et al., 2007b
<i>Aglaia rubiginosa</i>	Leaves	Androstane derivatives. 17-octanor-cycloartane-ring-A-seco acid Four cycloartane-type triterpenes and three unusual cholesterol derivatives	Weber et al., 2000
	Twigs	Cyclopental[b]benzofuran, 1- <i>O</i> -acetyl rocaglaol	Rivero-Cruz et al., 2004
<i>Aglaia silvestris</i>	Leaves, twigs and roots	Triterpenoids silvaglin A, B, methylisofoveolate B, methylfoveolate B, isosilvaglin A, B, desoxysilvaglin B, aglasilvinic acid, isoelchlerianic acid, methylfoveolate B, aglasilvinic acid, one pregnane steroid pregnacetal, two sesquiterpenes viridiflorol, α -muurolene	Pointinger et al., 2008
	Roots	Silvaglenamin-unusual dimeric triterpene structure with two dammarane units linked with an enaminic —NH— group	Hofer et al., 2009
<i>Aglaia smithii</i>	Bark	Dammarane triterpenoids, aglinone and aglinin E (20S,24S-epoxy-25-hydroxy-1-endammarane) along with three known compounds, 3- <i>epi</i> cotillol, aglinin A and eichlerianic acid	Harneti et al., 2012
<i>Aglaia spectabilis</i>	Bark	Rocaglamide derivatives	Schneider et al., 2000
	Leaves	Two bisamides secoisopiriferinol and secoisoodorinol	Greger et al., 2008
<i>Aglaia tenuicaulis</i>	Leaves, stem and root bark	Six amide-esters tenucaulin A, B, isotenucaulin A, aglatenin, tenaglin, caulinenin and two sulphur-containing bisamides pyrrolotenin, secopyrrolotenin	Greger et al., 2008
<i>Aglaia testicularis</i>	Leaves	Rocaglamide derivatives 1 and 2, one aglaine derivative aglaxiflorin D, two cinnamic acid-derived bisamides, piriferine and odorinol and a diarylbutane lignan, secoisolariciresinol dimethyl ether	Wang et al., 2004b
<i>Aglaia tomentosa</i>	Bark	Dammarames, aglinins C and D two pregnane steroids, aglatomins A and B and cyclopentate-trahydrobenzofuran, rocaglaol	Mohamad et al., 1999b
<i>Amoora rohituka</i>	Bark	Amoorinin	Agnihotri et al., 1987
	Stem bark	Guaiane-derived sesquiterpenoids, 6 β ,7 β -epoxyguai-4-en-3-one and 6 β ,7 β -epoxy-4 β ,5-dihydroxyguaiane.	Chowdhury et al., 2003b
	Seeds	7-Keto-octadec-cis-11-enoic acid	Daulatabad and Jamkhandi, 1997
<i>Aphanamixis grandifolia</i>	Leaves and twigs	Tirucallane triterpenoids, 2 α -ethoxy-2,3-secotirucalla-2,29-epoxy-7-ene-23-oxo-3-oic acid (1) and (23E)-2 α -hydroxytirucalla-7,23,25-triene-3-one and a tirucallane triterpenoid 2,3-secotirucalla-2,3; 2,29-diepoxy-7-ene-3,23-dione	Wang et al., 2012a
		Cycloartane triterpenoids, aphagrindinoids A-C and aphagrindin D, and (20R)-3 β -hydroxy-24,25,26,27-tetranor-5 α -cycloartan-23,21-olide	Wang et al., 2013

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Aphanamixis polystachya</i>	Leaves and stem	Terpenoids, nemoralisins D-G, diterpenoids, nemoralisin C and nemoralisin	Zhang et al., 2014
	Stem barks	Tirucallane type C ₂₆ triterpenoids, 3a-hydroxyl-21a-methoxy-24,25,26,27-tetranortirucall-7-ene-23(21)-lactone, 3a-hydroxy-21b-methoxy-24,25,26,27-tetranortirucall-7-ene-23(21)-lactone, 3-oxo-21a-methoxy-24,25,26,27-tetranortirucall-7-ene-23(21)-lactone, 3-oxo-21b-methoxy-24,25,26,27-tetranortirucall-7-ene-23(21)-lactone, and 3-oxo-21a-ethoxy-24,25,26,27-tetranortirucall-7-ene-23(21)-lactone	Zhang et al., 2010
	Stem	Tirucallane C27-triterpenoid epimers, aphaganins A and B	Wang et al., 2012b
		2,3-Seco-tirucallane triterpenoid derivatives aphanamgrandins A-F, three 3,4-seco-29-nor-tirucallane triterpenoid derivatives aphanamgrandins G-I, one 3,4-seco-tirucallane triterpenoid aphanamgrandin J, two tirucallane triterpenoids aphanamgrandin K and (23Z)-25-hydroxy-tirucalla-7,23-diene-3-one and three known triterpenoids (23S)-21,23-epoxy-5a-cycloart-24-en-3b-ol, 3b,25-dihydroxy-tirucalla-7,23-diene, and (–)-leucophyllone.	Zeng et al., 2012
	Fruits	Triterpenoid Aphanamgrandiol A	Zeng et al., 2013
	Stem bark	Limonoids aphanamolides C and D, aphanamolide A and aphapolynin A	Zhang et al., 2013a
		Diterpenes possessing rare five-membered peroxide ring, aphanaperoxides E-H	Wu et al., 2013
	Bark	Dihydroamoorinin	Agarwal et al., 2001
	Roots	Limonoids and flavonoids Amoorinin-3-O- α -l-rhamnopyranosyl-(1 to 6)- β -d-glucopyranoside, 8-methyl-7,2',4'-tri-O-methyl flavonone-5-O- α -l-rhamnopyranosyl-(1 to 4)- β -d-glucopyranosyl-(1 to 6)- β -d-glucopyranoside and 8-C-methyl-5,7,3',4'-tetrahydroxy flavone-3-O- α -l-arabino pyranoside	Srivastava et al., 2003
	Fruits	Ring A-seco limonoids, aphanalides A-H	Wang et al., 2012c
	Seed	Highly oxidized A,B-seco limonoids, aphapolynins A and B	Zhang et al., 2011
<i>Astrotrichilia asterotrichia</i>		Limonoids rohituka-12, rohituka-13 and rohituka-14 and kihadalactone A and known compounds polystachin, rohituka-7 and rohituka-9.	Mulholland and Naidoo, 1999
	Bark	Astrotrichilin	Mulholland et al., 1996
<i>Astrotrichilia voamatata</i>	Stem bark	Voamatins A and B	Mulholland et al., 1999a
	Stem bark	Voamatins C and D	Mulholland et al., 2000a
<i>Azadirachta indica</i>	Leaves	Nimboldine, 28-deoxonimbolide	Kigodi et al., 1989
<i>Azadirachta indica</i>		Nimbinene and 6-deacetyl nimbinene, nimbadiol, hyperoside, quercetin, rutin, meldenindiol, 4 α ,6 α -dihydroxy-A-homoazadiridine	Rastogi and Mehrotra, 1993
		Tetracyclic triterpenoids zafaral 24,25,26,27-tetranorapotirucalla-(apoerupa)-6 α -acetoxyl-1,14-dien-3,16-dione-21-al(1) and meliacinanhydride	Siddiqui et al., 2004
		24,25,26,27-tetranorapotirucalla-(apoerupa)-6 α -hydroxy, 11 α -methoxy-7 α ,12 α diacetoxyl,1,14,20(22)-trien-3-one (2)	
		Teetranortriterpenoids 24,25,26,27 tetranorapotirucalla-(apoerupa)-6 α -O-methyl, 7 α -S enecioyl (7-deacetyl)-1 α ,12 α ,21,23-tetrahydroxy-21,23-epoxy-2,14,20 (22)-trien-1,16-dione (1)	Siddiqui et al., 2003
	Seeds	Triterpenoids 22,23-dihydronimocinol and des furano-6 α -hydroxyazadiradione 1 α -Methoxy-1,2-dihydroepoxyazadiradione, 1 β ,2 β ,14 β ,15 β -diepoxyazadiradione, 7-acetylneotrichilenone, three C-7 benzoates of tetrnortriterpenoids (I, II, III), nimbin and β -sitosterol, nimbinene and 6-deacetyl nimbinene, nimbadiol	Siddiqui et al., 2002
		Tetranortriterpenoids 1 α ,2 α -epoxy-17 β -hydroxyazadiradione, 1 α ,2 α -epoxynimolicinol, 7-deacetyl nimolicinol	Rastogi and Mehrotra, 1993.
		Margocin, margocinin and margocilin	Hallur et al., 2002
	Root bark	Limocinol, limonone, limocin A and B, limocinin.	Ara et al., 1990
		7 α -acetoxyl-4,4,8-trimethyl-5 α -(13 α Me)-androsta-1,14-dien-3,16-dione,7 α -acetoxyl-4,4,8-trimethyl-5 α -(13 α Me)-17-oxa-androsta-1,14-dien-3,16-dione and 7 α -acetoxyl-4,4,8-trimethyl-5 α -17-oxa-androsta-1,14-dien-3,16-dione	Siddiqui et al., 1991
	Fruits	Nimolicinol	Siddiqui et al., 1992
<i>Azadirachta indica</i>	Nodal callus	Azadirachtin	Rastogi and Mehrotra, 1993
	Seed kernels	Azadirachtin derivatives, 29-oxymethylene azadirachtin analogue,29-oxymethylene-11-demethoxy-carbonyl-11- α -hydroxy azadirachtin (azadirachtin M), 22,23-dihydro-23 α hydroxy-3-tigloyl-11-deoxyazadirachtin (azadirachtin N)	Babu and Nair, 2004
		Apo-tirucallols, 1a,7a-diacetoxyl-17a-20S-21,24-epoxy-apotirucall-14-ene-3a,23R,24S,25-tetraol	Luo et al., 1999
	Seeds	11-Hydroxyazadirachtin-B, 1-tigloyl-3-acetylazadirachtin, 1,2-diacyl-7-tigloyl-12-hydroxy vilasinin and 23-desmethyl limocin-B	Luo et al., 2002
	Fruit coats	Azadireronolide, iso azadireronolide, azadiradionolide Tetracyclic triterpenoids, salimuzzalin, azadirolic acid, azadiradionol, azadireronol Tetranortriterpenoid, 11-epi-azadirachtin H	Kumar et al., 1996

Box 1 (Continued)

Plant	Part used	Compound	Reference
	Dried cells and seed kernel	Azadirachtin	Jarvis et al., 1997
	Flowers	Triterpenoid, 1 α ,7 α -diacetoxy apo tirucall-14-ene-3 α ,21,22,24,25-pentaol. Neeflone, a new tetranortriterpenoid-15-acetoxy-7-deacetoxydihydro azadione	Luo et al., 2000e Nanduri and Banstola, 1995
	Essential oil of flowers	Sesquiterpenes α -cubebene, copaene, humulene, δ -cadinene, 3,4-dimethylthiophene, dipropyl disulphide, nonanal, propyl propenyl disulphide, δ -elemene, α -gurjunene, linalool, caryophyllene, aromadendrene, <i>allo</i> -aromadendrene, viridiflorene, α -muurolene, δ -cadinene, bicyclogermacrene, <i>cis</i> -3,5-diethyl-1,2,4-trithiolane, cadina-1,4-diene, <i>trans</i> -3,5-diethyl-1,2,4-trithiolane, 2-tridecanone, calamene, α -calacorene, palustrol, ledol, nerolidol, ethyl laurate, cubenol, epicubenol, globulol, viridiflorol, τ -cadinol, τ -muurolol, phytol	Aromdee and Sriubolmas, 2006
<i>Azadirachta excelsa</i>	Stem	4 Meliacin type limonoids, two novel namely and 2,3-dihydronimboldine and 3-deoxy methyl nimbidate	Cui et al., 1998
<i>Cabralea canjerana</i>	Stem	Dammarane triterpenes 20S,24S-epoxy-7 β ,25-dihydroxy-3,4-secdammar-4(28)-en-3-oic acid, 20S,24S-epoxy-7 β ,15 α ,25-trihydroxy-3,4-secdammar-4(28)-en-3-oic acid and 20S,24R-epoxy-7 β ,22 α ,25-trihydroxy-3,4-secdammar-4(28)-en-3-oic acid, known dammarane triterpenes octocillone, eichlerianic acid, shoreic acid and the sterols sitosterol, campesterol, sitostenone stigmasterol, and stigmast-5-en-3-one	Campos Braga et al., 2006
	Branches	Ocotillone, eichlerianic acid, shoreic acid and eichlerialactone	Campos Braga et al., 2006 Fossen et al., 2012
<i>Capuronianthus mahafalen-sis</i>	Stem barks	Protolimonoid, capulin	
<i>Carapa guianensis</i>	Twig	1,3-Di-benzene carbon amine-2-octadecylic acid-glyceride (new), hexacosanoic acid,2,3-dihydroxy-glyceride (first time from natural source), ursolic acid, naringenin, scopoletin, 3,4-dihydroxymethylbenzoate, 2,6-dihydroxymethylbenzoate, tetratriacontanoic acid, triacontanoic acid.	Qi et al., 2004
	Flower oil	Mexicanolides and phragmalin-type limonoids named Andriolides A, B, C, D, E, F and G, with the known 7-deacetoxy-7-oxogedunin and 6 α -acetoxyguedunin Gedunins andirobin, three mexicanolides, and two phragmalin-type limonoids andirolides H, I, J, K, L, M, N, O, and P	Tanaka et al., 2011
	Flower oil	Gedunins, an andirobin, two mexicanolides, and a phragmalin-type limonoid, named andirolides Q, R, S, T, U and V	Tanaka et al., 2012
	Flower oil	Gedunoids, carapanolides A and B	Sakamoto et al., 2013
<i>Cedrela odorata</i>	Seeds	Tetranor tri tetraterpenoids, 3-deoxo-3 β , 8 β epoxy-6,14 α , dihydroxy-8,14 α -dihydromxi canolide, cedrodrorin: 3-deoxo-3 β , 8 β epoxy-6-14 α hydroxy-8, 14-dihydro mexicanolide, 6-acetoxy cedrodrorin: 3-deoxo-3 β , 8 β epoxy-6-14 α hydroxy-8, 14-dihydromexicanolide, 6-deoxy-9 α -hydroxy cedrodrorin and 3-deoxo-3 β ,8 β -epoxy-6,9 α , 14 α -di hydroxy-mexicanolide (9 α -hydroxy cedrodrorin)	Inoue et al., 2012 Veitch et al., 1999
	Leaves	Sesquiterpenoids: α -santalene, β -acoradiene, β -elemene caryophylleneoxide, Z- α -bergamotene	
	Leaf essential oil	Sesquiterpenes, triterpenes, limonoids and flavonoids	Asekun and Ekundayo, 1999
	Stems	Nomilin/obacunol derivatives 11 β -acetoxycobacunol acetate, 11 β ,19-diacetoxy-1-deacetyl-1-epidihydronomilin, 11 β -acetoxycobacunol and odoralide and swietenolide derivative 8 β ,14 α -dihydroswietenolide, and seven known limonoids of two nomilin derivatives, 7-acetyldehydronomilin, and 7-acetyl-11b-acetoxydihydronomilin, five mexicanolides, swietenolide, 3b,6-dihydroxydihydrocarapin, xylocensin K, 3b-hydroxydihydrocarapin and cedrodrorin	De Paula et al., 1997 Kipassa et al., 2008
	Stem bark	Sesquiterpene hydrocarbons and oxygenated sesquiterpenes 43.9%, 42.4% respectively. α -copaene (14.4%), α -cadinol (11.2%), β -eudesmol (9.4%), delta-cadinene (9.2%).	
	Bark oil	3-oxo-threo-23,24,25-tri hydroxy tirucall-7-ene and 3 β -O- δ -glucopyranosyl-24-methylene cholesterol	Martin et al., 2003
	Heart wood	Sesquiterpenes α -terpinyl acetate spathulenol, elemol, alismol	Campos et al., 1991
<i>Cedrela mexicana</i>	Leaves and stem		Ogunwande et al., 2005
<i>Cedrela sal-vadorensis</i>	bark oil		Barrios-Chica and Castro-Castillo, 1995
	Leaves	Flavonol rhamnosides-(–)-epicatechin, a fzelin and quercitrin	
<i>Cedrela sinensis</i>	Leaves	Cedrellin and 2,6,10,15-phytatetraene-14-01-	Luo et al., 2000a
	Seeds, leaves, and stems	Five limonoids:11 β -hydroxy-7 α -obacunyl acetate,11-oxo-7 α -obacunyl acetate, 11-oxo-7 α -obacunol, 11 β -hydroxycencorin G,11-oxocencorin G	Mitsui et al., 2004
	Rachis	Apotirucallane triterpenoids	Mitsui et al., 2005
		Methyl gallate, quercitrin, bis-(<i>p</i> -hydroxy phenyl)-ether adenosine, isoquercitrin, rutin, (+)-catechin and (–)-epicatechin	Park et al., 1996
<i>Cedrela tonduzii</i>	Leaves	Quercetin-3-glucoside 2 and robinin	Rastogi and Mehrotra, 1993
<i>Cedrela tubiflora</i>	Leaves	Water-soluble polysaccharide	Benencia et al., 1999

Box 1 (Continued)			
Plant	Part used	Compound	Reference
<i>Cedrelopsis grevei</i>	Trunk bark	Coumarins, 7-methoxy-5-prenyl coumarin (iso cedrelopsin) and 3,4'-dihydrobraylin, along with five known coumarins (6,7-dimethoxy-5-prenyl coumarin obliquin, 8-methoxy obliquin aesculetin, cedrelopsin and scoparone)	Um et al., 2003
<i>Chisocheton ceramicus</i>	Barks	Limnoid ceramicine A	Mohamad et al., 2008
<i>Chisocheton erythrocarpus</i>	Barks	Limonoids, erythrocarpines A-E	Awang et al., 2007
<i>Chisocheton paniculata</i>	Fruit	Limonoids, malayanine A and malayanine B Meliacin 1,2-dihydro-6-acetoxy azadirone	Chong et al., 2012 Bordoloi et al., 1993
<i>Chisocheton polyandrus</i>	Whole plant	Protolimonoids and limonoids arunachalin	Yadav et al., 1999
<i>Chisocheton tomentosus</i>	Leaves	Dammarane triterpenoids, dammara-20,24-dien-3-one and 24-hydroxydammara-20,25-dien-3-one	Chan et al., 2012
<i>Chukrasia tabularis</i>	Bark	7 α -Hydroxy- β -sitosterol (new), stigmasta-4,6-diene-3-one, stigmasterol and β -sitosterol	Najmuldeen et al., 2011
<i>Cipadessa baccifera</i>	Leaves	Sitosterol, melianone, scopoletin, 6,7-dimethoxy coumarin, quercetin and its 3-galactoside and tannic acid	Rastogi and Mehrotra, 1993
	Wood	Meliacins, chukrasin A, B, C, D and E	Rastogi and Mehrotra, 1993
	Stem bark	Phragmalin-type limonoids, tabulalin F 19-nor limonoid incorporating a unique 7,10-c-lactone tabulvelutin A, tabulvelutin B	Jun et al., 2011
	Root bark	Phragmalin limonoids tabulalin and tabulalides A-E	Yin et al., 2011
	Seeds	3,30-Isobutyrate, 3-isobutyrate, 30-propionate of phragmalin, 12-acetoxy phragmalin Linoleic, linolenic acid	Nakatani et al., 2004
	Leaves	Cipadessi n-type limonoids, cipaferens A-D, and asmelianodiol, spicatin	Rastogi and Mehrotra, 1993
	Seeds	Cipadesin, 17 α , 20R-dihydroxy pregnan-3,16-dione, 1,4-epoxy-16-hydroxy heneicos-1,3,12,14,18-pentaene and 1,4-epoxy-16-hydroxy heneicos-1,3,12,14-tetraene Cipadesin and febrifugin	Goel, 1998 Siva et al., 2013a
<i>Cipadessa boivinina</i>	Stem bark	Methyl angolensate type cipaferen E-J and three new mexicanolide-type limonoids cipaferen K-M Sesquiterpenoid; boivininan A (11,12,13-trisnorbisabol-1,3,5-trien-10,7-olide); boivininan B (7,10-epoxy-1,3,5-bisabolatrien-11-ol); 4-hydroxy-4,7-dimethyl-1-tetralone	Luo et al., 2000b Marpaung et al., 2001 Siva et al., 2013b
<i>Dysoxylum beddomei</i>	Leaves	Beddomeilactone, beddomeilactone together with six known triterpenoids (3-oxo tirucalla-7,24-dien-23-ol, dipterocarpol, niloticin, melianone, melianodiol and 24-epi-melianodiol)	Hisham et al., 2004
<i>Dysoxylum binectariferum</i>	Stem bark	Rohitukine	Mohanakumara et al., 2010
<i>Dysoxylum cumingianum</i>	Leaves	Dysoline, a regioisomer of rohitukine and rohitukine-N-oxide Triterpenes cumingianol A-E and a triterpene glucoside Cumingianoside R and hispidol B, 21-O-methylloosendanpentol and agladupol A	Jain et al., 2013 Kurimoto et al., 2011
<i>Dysoxylum densiflorum</i>	Twigs leaves	Three degraded limonoids, dysdensiols A-C, and three sesquiterpenoids, dysdensiols D-F, along with seventeen known compounds	Xie et al., 2008
<i>Dysoxylum grande</i>	Leaves	23-Oxo-cholestane derivatives grandol A-G along with a new 3,4-secdammar-4(28)-en-3-oxo acid derivative	Wah et al., 2013
<i>Dysoxylum hainanense</i>	Bark	Tirucallane derivatives. 3 β , 22S-dihydroxy tirucalla-7,24-dien-23-one, 22,23-epoxy-tirucalla-7-ene-3 β , 24,25-triol, 3 β ,25-dihydroxy-tirucalla-7,23-diene, 23,26-dihydroxy-tirucalla-7,24-diene-3	Luo et al., 2000c
		Ent-pimarene diterpenoids, ent-18-acetoxy-8(14)-pimarene-15S, 16-diol, ent-18-acetoxy-16-hydroxy-8(14)-pimarene-15-one, ent-16, 18-hydroxy-8(14)-pimarene-15-one, ent-19-nor-4,16, 18-trihydroxy-8(14)-pimarene-15-one together with three known damarane triterpenoids, richenoic acid, eichlerianic acid and shoreic acid.	Luo et al., 2001
		Apo-tirucallols 7 α -acetoxyl-17 α -20S-21,24-epoxy-apotirucall-14-ene-3 α ,23R,24S,25-tetraol (2), 7 α -acetoxyl-17 α -20S-21,24-epoxy-apotirucall-14-en-3-one-23R,24S,25-triol Nor-dammarane triterpenoids, 12 β -O-acetyl-15 α , 28-dihydroxy-17 β -methoxy-3-oxo-20,21,22-23,24,25,26,27-octanordammanran, 12 β -O-acetyl-15 α , 17 β ,28-trihydroxy-3-oxo-20,21,22-23,24,25,26,27-octanordammanran, 12 β -O-acetyl-15 α , 17 β ,28-trihydroxy-3-oxo-17-en-20,21,22-23,24,25,26,27-octanordammanran, and 12 β ,15 α ,17 β ,28-tetrahydroxy-3-oxo-20,21,22-23,24,25,26,27-octanordammanran	Luo et al., 2002 Wang and Guan, 2012

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Dysoxylum kuskusense</i>	Fruits	Prengleu desmane diterpenes, dysokusone I and dysokusone E	Duh et al., 2000
<i>Dysoxylum lenticellare</i>	Stem	2 α -methoxycomosivine, 2 α -methoxy lenticellarine and 2 α -hydroxylenticularine	Aladesanmi and Hoffmann, 1994
<i>Dysoxylum macranthum</i>	Bark	Biflavanoid, robusta flavone 4',7''-dimethyl ether, Isoginkgetin, bilobetin Triterpenes, dymacrins, A-Ktetracyclic terpenes and pregnane steroids	He et al., 1996
<i>Dysoxylum malabaricum</i>	Leaves	Dammarane triterpenoid dymalol (20S,24R)-epoxy-4-hydroxy-3,4-secodammaran-3-oic acid methyl ester (along with two known dammarane triterpenoids) Ergostane, ergosta 5,24 (24')-diene-3 β ,4 β , 20s-triol, (24R)-cycloartane-3 β -24,25-triol and ergosta-5,24 (24')-diene-3 β , 7 β -diol Terpenes, 21R,23R-epoxy-21 α -ethoxy-24S-25-dihydroxyapotirucall-7-en-3one 24R-acetoxy-3 β ,25-dihydroxy cycloartane	Mohammad et al., 1999b
<i>Dysoxylum mollissimum</i>	Leaves	Glabretal-type triterpenoids dysoxylumglabretol A (1a-1b), dysoxulumglabretol B (2a-2b) along with the known compounds, 24,25-epoxy-3b,23-dihydroxy-7-tirucallene (3), squalene, polyprenol, linoleic acid and lutein	Govindachari et al., 1997
<i>Dysoxylum muelleri</i>	Wood	Glabretal triterpenoids: Three dysoxins and also 6 α -acetoxy-obacunone acetate (limonoid) Dammarane triterpenoids cabraleone, and richenone	Hisham et al., 2001
<i>Dysoxylum richii</i>	Leaves	Dammarane triterpenoids	Ragasa et al., 2013
<i>Dysoxylum schiffneri</i>	Wood	Sesquiterpenoids (+)-8-hydroxy calamene, schiffnerone A (1,5-dihydroxy-1,3,5-bisabolatrien-10-one), trisa oresquiterpenoid, schiffnerone B (2-hydroxy-11,12,13-trinor-7-calamenone)	Mulholland et al., 1998a
<i>Dysoxylum spectabile</i>	Bark	Pimaradiene compounds, 6 α -acetoxyobacunol acetate, methyl ivorensate, isopimara-8(14),15-diene, and 7 α -hydroxisopimara-8(14),15-diene	Mulholland et al., 1999b
<i>Ekbergia benuguelensis</i>	Root bark	4-Methoxy-5-hydroxy methyl coumarin, together with poly hydroxy squalenes. 2,3,22,23-tetrahydroxy-2,6,10,15,19,23-hexamethyl-6,10,14,18-tetra cosa tetraene and 2-hydroxymethyl-2,3,22,23-tetrahydroxy-6,10,15,19,23-penta methyl-6,10,14,18-tetracosatetraene	Jonker et al., 1997
<i>Ekbergia capensis</i>	Dried bark	Triterpenoids, 2,3,22,23-tetra hydroxy 2,6,10,15,19,23-hexamethyl-6,10,14,18-tetracosatetraene and 2-hydroxy, methyl-23,22,23-tetrahydroxy 6,10,15,19,23-penta methyl-6,10,14,18-tetra cosa tetraene	Nishiyama et al., 1996
	Seed	Capensolactones 1-3 and methyl 3 α -hydroxy-3-deoxy angolensate	
<i>Ekebergia pterophylla</i>	Leaves	Lupeol	Mulholland and Iourine, 1998
	Bark	Pterophyllins 1 and 2 and known atraric acid, β -amyrin, β -amyrone, oleanonic acid, β -sitosterol, β -sitosteryl acetate and the Pterophyllins 3-5	Mulholland et al., 1998b
<i>Entandrophragma angolense</i>	Wood	Tirucallane triterpenoidal compounds 3,23-dioxotirucalla-7,24-dien-21-al, 3,4-secotirucalla-23-oxo-4(28),7,24-trien-21-al-3-oic acid and	Orisadipe et al., 2005
	Leaves	3,4-secotirucalla-23-oxo-4(28),7,24-trien-3,21-dioic acid (21-methyl ester)	
	Root bark	Two gedunin type limonoids 5-hydroxy-7-deacetoxy-7-oxogedunin and 5,6-dehydro-7-deacetoxy-7-oxogedunin, and three methyl angolensate derivatives, 6-deacetoxydomesticulide D, 6-deacetoxydomesticulide D 21-methylether, and entangosin, together with known compounds, methyl angolensate, 6-acetoxymethyl angolensate and secomahoganin	Nsiam et al., 2011
<i>Entandrophragma cylindricum</i>	Bark	Sesquiterpenes 3-hydroxy-copa-2-en (oil) and 2 α -hydroxy-copa-3-en	Daniewski et al., 1996
		Acyclic triterpene derivatives named sapelenins G-J, along with eight known compounds, sapelenins A-D, ekeberin D2, (+)-catechin and epicatechin and anderolide G	Kouam et al., 2012
<i>Entandrophragma delevoyi</i>	Stem bark	Delevoyin A (3,4-secotirucallane 4 (28),3-oic acid) and delevoyin B (6 α -acetoxykinadealactone)	Mulholland et al., 1994
	Bark	Acyclic triterpenoid, sapelenin D	Ngnokam et al., 1995
	Wood	A novel tetrnortriterpenoid, delevoyin C.	Mulholland et al., 2000b
<i>Entandrophragma utile</i>	Bark	Gedunin and 11 β -acetoxygedunin	Mulholland et al., 2000b
		A new heptanortriterpenoid, entilin D	Daniewski et al., 1995
		New sterol, 7 α ,20(S)-dihydroxy-4,24 (28)-er-gostadien-3-one	Tchouankeu et al., 1996
<i>Guarea macrophylla</i>	Leaves	Terpenes guai-6-en-10 β -ol, isopimara-7,15-dien-2 α -ol and cycloarta-23,25-dien-3-one.	Lago et al., 2000
	Leaves essential oil	Cycloartane triterpenoids including two new derivatives 22,25-dihydroxy-cycloart-23E-en-3-one and 24-methylenecycloartane-3b,22-diol	Lago et al., 2002a
	Leaves oil	Terpenes: one monoterpane, 16 sesquiterpenes and 6 diterpenes Sesquiterpenes identified including hydrocarbon and oxygenated derivatives	Lago et al., 2005

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Guarea guidonia</i>	Stem bark	Caryophyllene oxide, guai-6-en-10 β-ol, sphathulenol, aromadendrane-4α,10β-diol, aromadendrane-4α,10α-diol, alloaromadendrane-4α,10β diol, steroids: sitosterol and stigmasterol	Lago et al., 2002a
	Bark volatile oil	17 Sesquiterpenes, one diterpene and four fatty acids	
	Volatile oil	Sesquiterpene (2S*)-eudesma-5,7-dien-2-ol	Lago et al., 2002b
	Leaves	Triterpenes (23S*)-cycloart-24-ene-3b,23-diol and (23R*)-cycloart-24-ene-3b,23-diol	
<i>Guarea rhophalo-carpa</i>	Wood bark	Limonoid (mombasol) acumari (scopoletin) and sesquiterpenes	Garcez et al., 1998
	Stem bark oil	Sesquiterpenes, β-caryophyllene, germacrene	Nunez and Roque, 1999
<i>Guarea trichilioides</i>	Leaves	Terpenes including two sandara copimaraadiene diterpenoids, ent-8-(14), 15-sandaracopimaraadiene-2α,18-dioland ent-8-(14),15-sandaracopimaraadiene-2β 18-dioland two lanostane triterpenoids,23-hydroxy-5α-lanosta 7,9(11),24-triene-3-one and 5α-lanosta-7,9(11),24-triene-3α,23-diol	Del Rayo et al., 2001
<i>Khaya anthotheca</i>	Dried leaves	Cycloartane derivatives-cycloart-24-en-3,23-dione, 23-hydroxycycloart-24-en-3-one (epimers), 3β-hydroxycycloart-24-ene-23-one, 25-hydroxycycloart-23-en-3-one, 3β-21-dihydroxycycloartane, 3β-21,22,23-tetra hydroxycycloartane-24 (31)25-diene	Furlan et al., 1993
<i>Khaya grandifoliola</i>	Leaves	Diterpenoids including four labdane and two clerodane derivatives	Furlan et al., 1996
	Fruits	Diterpenoids including four labdane and two clerodane derivatives	Wolter et al., 1993
	Stems	Acy peroxylated and seco-mexicanolides 1α,8α-oxido-3β-acetoxy-2α, 14α-dihydroxy-{3,3,110,2}-bicyclo meliac-7,19-olide and 3-acetoxy 8,14-dien-8,30-sec-khaya lactone, methyl 1 α, 2β 3α, 6,8α, 14β-hexahydroxy {4,2,110,30, 11,4}-tricyclic limeliac-7-oate scopoletin and 3-β-d-gluco pyranosyl sitosterol	Ferreira et al., 2005
<i>Khaya ivorensis</i>	Stem bark	Anthothecanolide, 3-O-acetyl anthothecanolide, 2,3-di-O-acetyl anthothecanolide, 6R, 8α-dihydroxycarpin, 3β-acetoxy-3-deoxy-6Rhydroxycarpin, methyl angolensate, methyl 6-hydro angolensate, khaya lactone	Tchimene et al., 2005
	Trunk bark	A,B,D-Secolimonoid, khaya lactone ($C_{27}H_{34}O_9$)	Tchuendem et al., 1998
<i>Khaya senegalensis</i>	Stem bark	Deacetylkhyanolide E, 6S-hydroxykhyanolactone, and grandifolide A and khyanolide A, anthothecanolide, 3-O-acetylanthothecanolide	Zhang et al., 2008
	Bark	Limonoid 1-O-Deacetyl-6-deoxykhyanolide E, 1-O-deacetyl-2a-hydroxykhyanolide E, 3-acetyl-khyanolactone, 11a-acetoxy-2a-hydroxy-6-deoxy-destigloylwietinenine acetate,	Vanucci et al., 1992
<i>Malleastrum ants- ingyense</i>	Leaves	Rings B and D opened limonoids, rings B and D opened limonoids, khyanone and 2-hydroxy seneganolide and phragmalin limonoid 1-O-acetyl khyanolide Phragmalin-type limonoids, khyanolides A, B and C, four B,D-seco compounds, seneganolide, methyl angolensate and its 6-hydroxy and 6-acetoxy derivatives	Nakatani et al., 2001
	Seeds	B/D opened limonoids, phragmalin limonoids khyanolides D and E and one limonoid glucoside, khyanoside	Abdelgaleil et al., 2001
	Leaves	2,6-Dihydroxy fissionolide Tetranotriterpenoids of mexicanolide type: 2-hydroxymexicanolide, 6-deoxy destigloylwietinenine, 2,3-dihydroxy-3-deoxymexicanolide	Nakatani et al., 2002
	Seeds	Methyl-1α-acetoxy-3β,6,8α-trihydroxy-2α-methoxy-2β,14β-epoxy-tricyclomeliac-7-oateand methyl 1α-acetoxy-6,8α, 14β,30β-tetrahydroxy-3-oxo-tricyclomelin-C-7-oate Mexicanolide tetranortriterpenoids 2-hydroxymexicanolide, 6-deoxydestigloylwietinenine and 2,3-dihydroxy-3-deoxymexicanolide. In addition, mexicanolide, 3β-hydroxy-3-deoxymexicanolide, 3β-hydroxy-3-deoxycarpin, 6-hydroxy methyl angolensate, 3-acetyl-7-keto khivorin, 3-deacetyl khivorin and 3,7-dideacetyl khivorin	Khalid et al., 1998
<i>Melia azedarach</i>	Leaves	Vilasinin limonoids 1,3-diacetylvilasinin, 1,3-diacetyl-12a-hydroxy-7-tigloylvilasinin Meliacarpin derivatives (C-seco limonoids) 1,3-dicinnamoyl-11-hydroxymeliacarpin,1-cinnamoyl-3-methacrylyl-11-hydroxy-meliacarpin and 1-cinnamoyl-3-acetyl-11-hydroxymeliacarpin.	Govindachari et al., 1998
<i>Malleastrum ants- ingyense</i>	Stem	Dipenta decylketone, glycerol 1,3-bis-undec-9-enoate 2-do-dec-9-enoateand glycerol tri-tri dec-9-enoate Steroids (20S)-5,24(28)-ergostadiene-3α,7α,16β,20-tetrol (1), (20S)-5-ergostene-3β,7α,16β,20-tetrol (2), and 2α,3β-dihydro-5-pregnene-16-one and 5-stigmastene-3β,7α, 20-triol, 5-stigmastene-3β,7α-diol, and 2α,3α,16β-trihydroxy-5α-pregnane 20R-methacrylate	Coombes et al., 2008
	Roots	12-hydroxy amoora statone, 12-hydroxy amoora statin, 12-acetooxy amoora statin Teracyrlmelazolide A, melazolide A and teracyrlmelazolide B	Bohnenstengel et al., 1999
		Limonoids, azecins 1, 2, 3 and 4	Suhag et al., 2003
<i>Ahn et al., 1994</i>			
<i>Ambrosio and Guerriero, 2002</i>			
<i>Srivastava and Gupta, 1985</i>			

Box 1 (Continued)

Plant	Part used	Compound	Reference
	Root bark	Azadararide 12 α -acetoxy fraxinellone, fraxinellone, fraxinellonone Salannai, meliacarpinin E, salannin, nimbolinin B, nimbolidin B Azadarachin C Azadirachtin type limonoids: 1-tigloyl-3,20-diacetyl-11-methoxy meliacarpinin, 3-tigloyl-1,20-diacetyl-11-methoxy meliacarpinin, 1-cinnamoyl-3-hydroxy-11-methoxy melia carpinin, 1-deoxy-3-methacrylyl-11-methoxy meliacarpinin, 1-cinnamoyl-3-acetyl-11-methoxy melia carpinin Azadirachtin type limonoids, 1-tigloyl-3-acetyl-11-methoxy meliacarpinin and 1-acetyl-3-tigloyl-11-methoxy meliacarpinin, sendanin type limonoids, 29-isobutyl sendanin, 12-hydroxy amoorastin, 29-deacetyl sendanin Trichilin H, 12-acetyltrichilin B, 7,12 diacetyl trichilin B, trichilin B and D, meliatoxin A2 Meliarteenin Limonoids and one tirucallane-triterpenoid C-Seco limonoids and new tetracyclic limonoids New ring C-seco limonoids	Nakatani et al., 1998 Ruo Chun et al., 1996 Huang et al., 1995 Takeya et al., 1996 Itokawa et al., 1995 Nakatani et al., 1994 Carpinella et al., 2002 Akhis et al., 2013 Zhou et al., 2005 Zhou et al., 2004 Pettit et al., 2002 Puroshothaman et al., 1984 Srivastava and Srivastava, 1996
<i>Melia dubia</i>	Bark	Meliastatins 1-5	Pettit et al., 2002
	Roots	Tetranortriterpenoids	Puroshothaman et al., 1984
<i>Melia composita</i>	Roots	Anthroquinones and glycosyl derivative of ellagic acid	Srivastava and Srivastava, 1996
<i>Melia toosendan</i>	Stem bark	Trichilins K and L, along with five known limonoids, trichilins H, I and J, azedarachin A and 12-O-acetyl-azedarachin B.	Zhou et al., 1996
	Root bark	Ring C-seco limonoids, 3-O-acetyllochinal, ohchinolide C and nimbolidin F, salannin, azadirone and acetyl trichilenone Limonoids with a C-19/C-29 bridged acetyl trichilin H 29-O-substituted amoorastatone derivatives neoazedarachs A, B and D Limonoids spirosendan, trichilinin D-E, and 1-deacetyl nimbolinin A, nimbolinin B and its 1-deacetyl derivative Toosendanal and 12-O-methylvolkensin, meliatoxin B, trichilin H and toosendanin 12-O-methyl-1-O-deacetyl nimbolinin B, 12-O-methy-1-O-tigloyl-1-O-deacetyl nimbolinin B, 12-O-ethyl nimbolinin B, and 1-O-cinnamoyl-1-O-debenzylochinal and tirucallane-type triterpenoids, meliasenins S and T Meliatoosenins E-S Nimbolinin-type limonoids, 12a/b-1-O-tigloyl-1-O-deacetyl-nimbolinin B, 1-deacetyl nimbolinin B, nimbolinin B and nimbolinin A Limonoids Apotirucallane triterpenes meliavolkensins A and B, toosendanin and meliavolen, melianinone, 3-episapelin A, nimbolin B Meliavolin, apotirucallane triterpene, and meliavolkin, tetranortriterpene, together with melianin A, Ring C-seco limonoids, nimbolidins C-E along with known Seco-limonoids, nimbolidin B and salannin Volkensinin ($C_{32}H_{42}O_{11}$) Antimycobacterial triterpenes, 12 β -hydroxykulactone(1)6 β -hydroxykulactone (2)	Zhou et al., 1997 Zhou et al., 1998 Nakatani et al., 1999 Tada et al., 1999 Hu et al., 2011 Zhang et al., 2012b Su et al., 2013 Zhang et al., 2013b Zeng et al., 1995a Zeng et al., 1995b Nakatani et al., 1996 Rogers et al., 1998 Cantrell et al., 1999
<i>Melia volkensi</i>	Root bark	Fruits	Zhang et al., 2013b Zeng et al., 1995a Zeng et al., 1995b Nakatani et al., 1996 Rogers et al., 1998 Cantrell et al., 1999
<i>Melicope semicarpifolia</i>	Leaves	Furoquinoline alkaloids and cytotoxic constituents. Meliacarpine, semecarpine and (+/-)-8-methoxyplatydesmine, together with flavone ayanin	Chen et al., 2003
<i>Munronia delavayi</i>	Whole plants	Limonoids, mulavanins A-E, along with four known compounds 2 α ,3 α ,15 β -trihydroxy-20(S)-tigloyl-pregnane, mombasol, 14,15 β -epoxyxprieurianin and nymania 3	Lin et al., 2010
<i>Munronia henryi</i>	Whole plant	A,B-seco-tetranortriterpenoid lactam, munroniamide	Qi et al., 2003
<i>Munronia unifoliolata</i>	Whole plant	Limonoids munronolide, munronolide 21-O- β -d-glucopyranoside Limonoids, named munronoids A-J	Zhang et al., 2004 Ge et al., 2012
<i>Neobeguea leandreana</i>	Stem bark	Phragmalin limonoids leandrenans A, B and C	Coombes et al., 2003
<i>Neobegueae mahafalensis</i>	Bark	Limonoid, neobeguin, and β -amyrin and stigmasterol	Randrianarivelojosia et al., 1999
<i>Owenia cependora</i>	Seed shells Seed Leaves and bark	Three triterpenoids, sapelin C, sapelin E acetate and grandifoliole none Methyl angolensate, mexicanolide and khayasin Limonoid, 28-deoxonimbolide, and three protolimonoids, 24S,25-dihydroxytirucall-7-en-3-one, 3-oxo-tirucalla-7, 24-dien-21-al and 21,24R-epoxy-25-hydroxytirucall-7-en-3-one	Naidoo et al., 2003 Mulholland et al., 1998c
<i>Quivisia papinae</i>	Seeds	Limonoid quivisanthone, and 6 α -hydroxyazadiradione and 7-deacetyl-7-angeloyl-6 α -hydroxyazadiradione, azadiradione Mexacanolide limonoids, quivisanolide A, quivisanolide B and quivisanone	Coombes et al., 2004. Coombes et al., 2005.

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Sandoricum indicum</i>	Stem bark	Multiflorane-triterpenoid acids 12 β -hydroxy multiflorane triterpenoid acids, sandorinic acids A-C	Tanaka et al., 2001
<i>Sandoricum koetjape</i>	Leaves	Trijugin type limonoids, sandrapins A, B and C	Ismail et al., 2003
		Analogues of trijugin type limonoids sandrapins D and E Andirobin-type limonoids, named sandoripin A and sandoripin B	Ismail et al., 2004 Pancharoen et al., 2009
	Stem bark	Secomultiflorane type triterpenoid acids, bryonic acid and two new ring-A seco triterpenoids	Kosela et al., 1995
<i>Soymida febrifuga</i>	Root callus	Methyl angolensate and luteolin-7-O-glucoside	Chiruvella et al., 2007
	Bark	Phragmalin type limonoids soymidin A and B.	Ashok Yadav et al., 2012
<i>Swietenia macrophylla</i>	Leaves	Phragmalin ortho esters, named swietephragmin H-J, and polyhydroxylated phragmalin, swietemacrophine	Tan et al., 2009
	Fruits	Phragmalin-type limonoid, 6-O-acetyl-3'-demethylswietephragmin E	Chen et al., 2010
	Seeds	Tetranortriterpenoids	Kojima et al., 1998
		Limonoids; augustineolide, 3 β -6 dihydroxy dihydrocarpin from <i>S. macrophylla</i> and 6-acetoxy humilinolide from aubrevillena	Mootoo et al., 1999
<i>Swietenia mahagoni</i>	Leaves	Scopoletin, melianone, cyclo mehogenol, swietenin, stigmasterol glucose	Rastogi and Mehrotra, 1993
		Phragmalin limonoids swietephragmins A-G, and two other different types of 2-hydroxy-3-O-tigloylswietenolide and deacetylsecocomahoganin, methyl 6-hydroxyangolensate, switemahonin G and 7-deacetox-7-oxogedunin	Abdelgaleil et al., 2006
	Twigs and leaves	Phragmalin-type limonoids, swietephragmin H, swietephragmin I and 11-hydroxyswietephragmin B, and a mexicanolide-type limonoid	Abdelgaleil et al., 2013
	Stem bark	2-hydroxy-6-deacetoxyswietenine 6-O-acetyl-2-hydroxyswietenin, 2-hydroxyswietenine, switemahonin G, methyl 6-hydroxyangolensate and 7-deacetox-7-oxogedunin	
	Heart wood	Limonoids, swiemahogins A and B	Chen et al., 2007
		Phragmalin 8,9,14-orthoacetate with the addition of methyl 2,30-orthoacetate or a propionate, swietenialides A, B, and C and two ring-D opened phragmalin-type 1,8,9-orthoacetates, swietenialides D and E, mexicanolide, 2-hydroxyswietenin	Saad et al., 2003
		Cyclo swietenol, upleol, benzoate hedergenin, cycloartenol, β -sitosterol	
	Seeds	6-Desoxyswietenine	Rastogi and Mehrotra, 1993
<i>Toona ciliata</i>	Leaves	Limonoids, toonayunnanins A-L	Govindachari et al., 1999a
	Leaves and stems	Siderin, 4,6,7-trimethoxy-5-methylcoumarin, isoscopoletin, scopoletin, 6,7-dimethoxycoumarin, 7-hydroxy-6,8-dime-thoxycoumarin, dehydrodiconiferyl alcohol, (–)-laricresinol, thero-2,3-bis-(4-hydroxy-3-methoxypheyl)-3-methoxy-propa-nol, cycloecalenol, 8(14), 15-isopimaradiene-2,3,19-triol, 3S,5R-dihydroxy-6R, 7-megstigmadien-9-one, (–)-loliolide, (+)-catechin, dimethyl malate, diisobutyl phthalate, dibutyl phthalate, 1,3,5-trimethoxybenzene, syringic acid, syringaldehyde, vanillic acid, vanillin, and 3,3',5,5'-tetra-tert-butyl-2',2'-dihydroxybiphenyl	Liu et al., 2012
		Toonacilianins A-J, and two norlimonoids, toonacilianins K and L	Liu et al., 2011a
	Stem	Five new pregnane steroids, toonasterones A, B, (Z)-aglawone, (Z)-toonasterone C, and (E)-toonasterone C	Liu et al., 2011b
	Stem bark		Wang et al., 2011
<i>Toona microcarpa</i>	Stem and bark	A flavanone, (+)-catechin, two lignans, (6R,7S,8S)-7a-[(β -d-glucopyranosyl)oxy]lyoniresinol and (6R,7R,8R)-7a-[(β -d-glucopyranosyl)oxy]lyoniresinol and a steroid 20-hydroxyecdysone	Fang et al., 2010
<i>Trichilia americana</i>	Stem	Steroid 2-hydroxyandrost-1,4-dien-3,16-dione (trichiliasterone B)	Hantos et al., 2001
<i>Trichilia casaretti</i>	Leaves	β -sitosterol, stigmasterol	Faaigueiredo, 2010
<i>Trichilia catigua</i>	Bark	Gamma lactones and its precursors omega-phenylalkanes, three omega phenyl alkanoic acids. Five omega-phenyl-gamma lactones, two alkyl-gammalactones, one alkenyl-gamma lactone and mixture of fatty acids ranging from C-14 to C-26	Pizzolatti et al., 2004
	Whole plant	7-Hydroxy-1-oxo-14-norcalamenene, 7,14-dihydroxy calamenene, sitosteryl- β - δ -glucopyranoside	Garcez et al., 1997a
	Fruits	Meliacin-type limonoids fotogedunin A, B	Matos et al., 2009
	Seeds	Methyl angolensate, 11 β -methoxycedrelone	Matos et al., 2007
<i>Trichilia clausenii</i>	Leaves	24-Methylene-26-hydroxycycloartan-3-one, 24-methylene cycloartanol fatty acids derivatives, caryophyllene epoxide, a mixture of ω -phenyl alkanoic and alkenoic acids, plastocromenol, α -tocopherol, squalene and a mixture of sitosterol and stigmasterol	Pupo et al., 1996
	Fruits	3-O- β -glycopyranoside sitosterol, 3-O- β -glycopyranoside stigmasterol β -Sitosterol etherified, stigmasterol etherified γ -Lactones (2R,3S,4S)-3-hydroxy-4-methyl-2-(13'-phenyl-1'-n-tride cyl)-butanolide. (2R,3S,4S)-3-hydroxy-4-methyl-2-(1'-phenyl-1'-n-undecyl)-butanolide. (2R,3S,4S)-3-hydroxy-4-methyl-2-(1'-n-hexa dec-7'(z)-enyl)-butanolide and (2R,3S,4S)-3-hydroxy-4-methyl-2-(1'-n-tetra decyl)-butanolide	Pupo et al., 1997 Pupo et al., 2002 Pupo et al., 1998

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Trichilia connaroides</i>	Wood	2 α ,3 α -dihydroxyandrostan-16-one-2 β ,19-hemiketal,2 α ,3 β -dihydroxypregn-16-one-2 β ,19-hemiketal,2 β ,3 β ,4 β -trihydroxypregn-16-one,2 α ,3 α ,4 β -trihydroxypregn-16-one,2 β ,3 β -dihydroxypregn-16-one	Pupo et al., 1997
	Leaves	Heynic acid and 24-methylene cycloartane-3 β , 21-diol	Rastogi and Mehrotra, 1993
	Leaves	Methyl 11',13'-dioxo-12'-aza-[4,4,3]-pro, 4a,8a-(methaniminomethano)naphthalene-9,11, naphthalene, bicyclo[3.1.1]2,6,6-trimethyl heptan-3-one, isotridecanol, 7-tetradecene, octane, 1-bromo-2-chloro-1,1-difluoro-2-tridecan (hexacosane), tetrahydroxy myrcenol, dodecyl acrylate (oleic acid), 1-(1,5-dimethyl)-4-hexyl-4-methyl benzene, 17-pentatriacontane, 2,4-bis(1,1-dimethyl ethyl) phenol, silane-trichlorodocosyl, -undecanethiol, 2-methyl, pentadecane, undecane, decane, hydroxylamine, o-decyl, dodecanoic acid, 2-hexyl-1-octanol, germacrane-B, erucic acid, phthalic acid, cyclobetyl octyl ester, nonadecane, hexadecanoic acid methyl ester (palmitic acid), serverogenin acetate, dotriacontane, isochiapin B, phytol, oleic acid, ethyl linoleate, ethyl oleate, 2-(3-innoxyl)3-aminopyridol (2,3-dipyrimidine), 4,4',6,6'-tetra-butyl O,O'-biphenol, eicosane, phthalic acid octyl tridec-2-yn-1-yl ester, 6,10,14,18,22-tetra cosa pentane 2-ol, 3-bromo,2,6,10,15, lycopersen, solanesol	Senthilkumar et al., 2012
	Twigs and leaves	Trijugins D-H and methyl 8a-hydroxy-8,30-dihydroangolensate, two degraded limonoids, trichiconnarin A and B, and a pregnane steroid, 3b,4a-dihydroxypregn-21-one, along with the known trijugin C and 3b,4a-dihydroxypregn-16-one	Wang et al., 2008
<i>Trichilia cuneata</i>	Pericarp	Mexicanolide type limonoid, 2-hydroxy-3-O-tigloyl-6-O-acetyl swietenolide and tirucallane type triterpenoid derivative, lipo-3-epi sapelin A	Inada et al., 1994
	Stem and leaves	13-acetoxy-14-nordehydrococalohastine, maturinone	Doe et al., 2005
<i>Trichilia dregeana</i>	Stem	Limonoids with furan-ringdregeana-5, dregeanin, 12-(2'-deacetyl)-dregeanin	Connolly et al., 1976
<i>Trichilia elegans</i>	Seeds	Limonoids with furan-ring, dregeana 1-4, hispidin C	Mulholland and Taylor, 1980
	Seed and bark	seco-A ring protolimonoids	Garcez et al., 1996
	Seeds	Limonoids seco-A, B and D carbocyclic rings, kihadanin A and B, 3-O- β -d-glucopyranosyl-sitosterol	Garcez et al., 1997b
<i>Trichilia emetica</i>	Seeds	7-Deoxo-7 β -acetoxylkihadanin A, B, 7-deoxo-7 β -hidroxykihadanin A, B, 7-deoxo-7 α -hidroxykihadanin A, 7-deoxo-7 α -acetoxylkihadanin A, B	Garcez et al., 2000
	Stem bark	Nymanial, drageane 4, trichilin A, rohituka 3, trichilin B and a protolimonoid	Gunatilaka et al., 1998
	Roots	Four pregnanes: 1-methoxy-pregnan-17(R)-1,4-dien-3,16-dione, 1-methoxy-pregnan-17(S)-1,4-dien-3,16-dione, 2,3-seco-pregnan-17(S)-2,3-dioic acid-16-oxo-dimethyl ester, 2 α ,3 α ,16 α -trihydroxy-5 α -pregnan-17(R)-20-yl acetate, three androstanes: 1-methoxy-androstan-1,4-dien-3,16-dione, 2,3-seco-androstan-2,3-dioic acid-16-oxo-dimethyl ester, 3-methoxycarbonyl-2,3-seco-androstan-3-oic acid-16-oxo-2,19-lactone, pregnane derivatives 2 α ,3 α ,16 α ,20-tetrahydroxy-5 α -pregnane, 2 β ,3 β -dihydroxypregn-16-one, 2 β ,3 α -dihydroxypregn-16-one	Malafronte et al., 2013
<i>Trichilia estipulata</i>	Leaves	7-oxo-24 α -sitosterol, β -sitosterol, sitosterone	Cortez et al., 1998a
	Bark	Lignan glycosides. (–)-isolariciresinol-3 α -O- β -d-xylopyranoside, (–)-lyoniresinol-3 α -O- β -d-xylopyranoside and the new lignans (+)-4'-O-methyl-9'-deoxy isolari ciresinol-3 α -O- β -d-glucopyranoside, (–)-lyoniresinol-3 α -l-rhamnopyranoside Meliacin butenolides, 7a-23-dihydroxy-3-oxo-24,25,26,27-tetranorapotirucall- 1,14,20(22)-trien-21,23-olide, 7-deacetyl-23-hydroxyneotrichilenonelide and 7-deacetyl-21-hydroxyneotrichilenonelide, together with scopoletin, isofraxidin, 7-oxo-24 β -, 7-oxo-24 α -sitosterols and 3 β -O- β -d-glucopyranosylsitosterol	Cortez et al., 1998a
	Stem bark	Limonoid 21,24,25,26,27-pentanor-15,22-oxo-7 α ,23-dihydroxy-apotirucalla-1-en-3-one 21,24,25,26,27-pentanor-15,22-oxo-7 α ,23-dihydroxy-apotirucalla-1-en-3-oen	Cortez et al., 2000
<i>Trichilia havanensis</i>	Seeds	Tetranortriterpenoid 1 β ,2 β : 21,23 diepoxy 7 α -hydroxy-24,25,26,27 tetranor-apotirucalla-14,20,22-trien-3-one Trichavensin	Rodriguez et al., 2003
		Hydroxybutenolide	Rodriguez-Hahn et al., 1996
	Stem	Limonoid neo-havanensis	Arenas and Rodrigues-Hahn, 1990
Stem and fruit		Limonoid triacetyl-havanensis, trichilene acetate	Chan et al., 1967
	Fruits	Carda-14,20(22)-dienolide-1,3,7-tris(acetyloxy)-21-hydroxy-4,4,8-trimethyl- α ,3 α ,5 α ,7 α ,13 α ,17 α ,21 R	Arenas and Rodrigues-Hahn, 1990

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Trichilia hirta</i>	Fruits	Limonoid 3,7-diacetyl-havanensis, havanensis Hirtinone, six protolimonoids – nilocitin, dihydronilocitin B, melianone epimers, piscidinol A, melianone lactone, one tritanortriterpenoid, hirtin, and one sesquiterpene, spathulenol A limonoid methyl-11 β -acetoxyl-6,23-dihydroxy-12 α (2-methylpropionyloxy)-3,7,21-triexo-1,5,14,20-meliacatetraen-29-oate	Chan et al., 1967 Vieira et al., 2013
	Seeds and leaves	Hirtine	Cortez et al., 1992
	Seeds and fruits	Deacetyl hirtine, azadirone	Chan and Taylor, 1966 Chan and Taylor, 1966
<i>Trichilia lepidota</i>	Leaves	Terpenes: epoxide caryophyllene, epoxide humulene, spathulenol and steroids: ergost-5,24(28)-dien-3,12-diol-(3 β ,12 β), ergost-5,24(28)-diene-3,12-diol-3-hexadecanoate (3 β ,12 β), 24-methyl-12 β -hydroxycolest-4-en-3-one, 24-methylen-colesterol	Pupo et al., 2002
<i>Trichilia pallida</i>	Leaves	24-methylen-3 β ,4 β ,22-trihydroxycolesterol, 24-methylen-3 β ,22-dihydroxycolesterol, 24-methylen-colesterol	Cunha et al., 2008
	Roots	Tetrnortriterpoids 6-hydroxy-11 β -acetoxyl-12 α (2-methylpropanoyloxy)-3,7-dioxo-14 β ,15 β -epoxy-1,5-meliacadien-29-oate, methyl 6,11 β -dihydroxy-12 α (2-methylpropanoyloxy)-3,7-dioxo-14 β ,15 β -epoxy-1,5-meliacadien-29-oate	Simmonds et al., 2001
<i>Trichilia prieuriana</i>	Leaves	Protolimonoid glucoside, prieurianoside, and glycolipid 1,2-dilinolenoyl-3-galactopyranosylglycerol	Olugbade and Adesanya, 2000
<i>Trichilia quadrijuga</i>	Stem	Prieurianin acetate and prieurianin	Gullo et al., 1975
<i>Trichilia rubra</i>	Leaves	Terpenes: kudtdiol, spathulenol and steroids, β -sitosterol, itesmol, stigmasterol	Rodrigues et al., 2009
<i>Trichilia rubescens</i>	Root	Three minor limonoid components, rubralins A-C Limonoids rubrin A, B, C, D, E, F and G	Musza et al., 1995
<i>Trichilia silvatica</i>	Leaves	trichirubun A, trichirubun B	Musza et al., 1994
<i>Trichilia welwitschii</i>	Seeds	(2S,3S,6R,7R)-humulene-2,3,6,7-diepoxide, (2R,3R,6R,7R)-humulene-2,3,6,7-diepoxide, mustacone	Krief et al., 2004, 2006
<i>Turraea floribunda</i>	Bark	Limonoids, dregeanin DM4, rohituka 3 and trichilia lactone D5	Souza et al., 2009
<i>Turraea holsti</i>	Seed	28,29-dinorcy cloar-24-ene-3,4,6-triol (4), sitosterol-3-O- β -d-glucoside, 4-hydroxy-N-methyl-l-proline, stigmasterol and sitosterol	Tsamo et al., 2013
<i>Turraea floribunda</i>	Root bark	Limonoids and limonoid derivatives, turraflorins D-I, turraflorins A and B	McFarland et al., 2004
<i>Turraea holsti</i>	Root bark	11 β -acetoxyl-3,7-diacetyl-4 α -carbomethoxy-12 α -isobutyryloxy-28-nor-1-tigloyl-havanensis	Torto et al., 1996
<i>Turraea holsti</i>	Stem and root bark	Limonoids of the havanensis class Triterpenoids, holstinone A. (21R,23R-epoxy-7 α ,24S-dihydroxy-21 α ,25-dimethoxyapotirucalla-1,14-dien-3-one), holstinone B (21S,23R-epoxy-7 α ,24S,25-trihydroxy-21 β -methoxyapotirucalla-1,14-dien-3-one) and holstinone C (21R,23R-epoxy-7 α ,24S,25-trihydroxy-21 α -methoxyapotirucalla-1,14-dien-3-one).	Torto et al., 1995 Mulholland et al., 1999c
<i>Turraea parvifolia</i>	Root bark	Vilasinin limonoids, 1 α ,3 α -diacetyl vilasinin, 1 α -acetyl-3 α -propionyl vilasinin and 1 α ,3 α -diacetyl-7 α -tigloyl vilasinin, and two azadirone limonoids mzikonone and 12 α -acetoxyl-1,2-dihydroazadirone	Cheplogoi and Mulholland, 2003a
<i>Turraea pubescens</i>	Seeds	Turraparvin A-D, 12 α -acetoxyl azadirone, 11-epi-21-hydroxytoonacilide, 11-epi-23-hydroxytoonacilide	Cheplogoi and Mulholland, 2003b
<i>Turraea pubescens</i>	Twigs and leaves	Pregnane steroids, 2 β ,3 β ,5 β -trihydroxy-pregn-20-en-6-one, 3 β -hydroxy-5 α -pregn-7,20-dien-6-one, and 3 β -acetoxyl-5 α -pregn-7,20-dien-6-one	Wang et al., 2006
<i>Turraea wakefieldii</i>	Twigs	3 β -hydroxy-5 α -pregn-7,20-dien-6-one Steroids turranin A-C and one new sesquiterpene turranin F and two new natural products turranin D and E, as well as three known steroids villosterol, 3 β -hydroxy-5 α -pregn-7,20-dien-6-one, and 2 β ,3 β ,5 β -trihydroxyxypregn-20-en-6-one	Yuan et al., 2013
<i>Turraeanthus manni</i>	Root bark	Limonoids 11 β ,12 α -diacetoxynonetecleanin, 11 β ,12 α -diacetoxyl-14 β ,15 β -epoxyneotecleanin, 7 α ,12 α -diacetoxyl-14 β ,15 β -epoxy-11 β -hydroxyneotecleanin, 7 α ,12 α -diacetoxyl-11 β -hydroxyneotecleanin, 11 β ,12 α -diacetoxyl-1-deoxo-14 β ,15 β -epoxy-3 β -hydroxy-2-oxo-neotecleanin (3R,4R,3' R,4' R)-6,6'-dimethoxy-3,4,3',4'-tetrahydro-2H,20H-[3,3']bichromenyl-4,40-diol and 15-acetoxy-labda-8(17),12E,14Z-trien-16-alcoumarin derivative, chromenone, two labdane diterpenes and one pregnane steroid	Ndung'u et al., 2003
<i>Turraeanthus africanus</i>	Root bark	Two labdane diterpenoids and seco-tetranortriterpenoid.	Sielinou et al., 2012
<i>Turraeanthus africanus</i>	Seeds	12,15-epoxylabda-8(17),12,14-trien-16al and 16-acetoxy-12(R),15-epoxy-15 β -hydroxylabda-8 (17), 13 (16)-diene and a limonoid 17-epi-12-dehydroxy heudebolin	Tane et al., 2004
<i>Walsura chrysogyna</i>	Barks	Limonoids walsogyne A	Mohamad et al., 2008
		Limonoids, Walsogynes B-G	Nugroho et al., 2013

Box 1 (Continued)

Plant	Part used	Compound	Reference
<i>Walsura piscidia</i>	Leaves	Piscidinol F, apotirucallane	Govindachari et al., 1995
	Aerial parts	Lup-20-(29)-ene-3β,30-diol and 5-hydroxy-7,3',4',5'-tetra methoxy flavones	Balakrishna et al., 1995
<i>Walsura robusta</i>	Leaves	Sesquiterpenoid 10β-nitro-isodauc-3-en-15-al, 10-oxo-isodauc-3-en-15-al	Li et al., 2013a
<i>Walsura trichostemon</i>	Roots	Apotirucallane, trichostemonate	Sichaem et al., 2012
<i>Walsura trifoliata</i>	Leaves and twigs	Apo-tirucallane triterpenoids, piscidinone A and B	Rao et al., 2012
<i>Walsura yunnanensis</i>	Bark	Walsurin, isowalsuranolide, 11β-acetoxy walsuranolide and 20,22-dihydro-22,23-epoxy walsuranolide and 11β-hydroxy dihydrocedrelone, 11β-acetoxy dihydrocedrelone	Luo et al., 2000d
<i>Xylocarpus granatum</i>	Bark	Friedelin, β-sitosterol, stigmasterol, methyl-3β-isopropyl-1-oxomeliolate, methyl-3β-acetoxy-oxomeliolate tria contanol	Rastogi and Mehrotra, 1993
		Phragmalin-type limonoids, xyloccensins Q-U along with xyloccensin P	Cui et al., 2005
		Three mexicanolides, xyloccensins L-N and eight 8, 9, 30-phragmalin ortho esters, named xyloccensins O-V	Wu et al., 2006
<i>Xylocarpus moluccensis</i>	Fruit	Xyloccensin K, W, aurantiamide, daucosterol, (β)-catechin, spicatin, 6-acetoxycedrodrorin	Wu et al., 2006
	Seeds	Xyloccensin K Seven protolimonoids odoratone, grandifoliolenone, sapelin E acetate, holstinone B, C, hispidol B, piscidinol G	Kokpol et al., 1996
	Seeds	Xyloccensins A, B, C, D, E, F and methyl angolensate	Rastogi and Mehrotra, 1993
		Godavarins A-J along with eight known limonoids, viz. xyloccensins L, P, Q, mexicanolide, 6-deoxy-3-detigloyl-swietenine acetate, fissinolide, methyl 3β-acetoxy-1-oxomeliaca-8(30), 14-dienoate, and methyl 3β-acetoxy-1-oxomeliaca-8(9),14-dienoate	Li et al., 2010
		Thaixylomolins D-F	Li et al., 2013b

Box 2: Antibacterial and antifungal activity of Meliaceae members.

Plant name	Part used	Extract	Microbes used	Reference
<i>Agalia congylos</i>	Leaf and bark	Hexane, dichloromethane, methanol	<i>Saccharomyces cerevisiae</i> , <i>Escherichia coli</i> , <i>Bacillus subtilis</i> , <i>Bacillus cereus</i>	Jayasinghe et al., 2002
<i>Aglaia cucullata</i>	Leaf	Methanol, chloroform:methanol, chloroform, Hexane	<i>Vibrio alginolyticus</i> , <i>Pseudomonas aeruginosa</i> , <i>Edwardsiella tarda</i> , <i>Pseudomonas fluorescens</i>	Choudhury et al., 2005
<i>Amoora chittagongia</i>	Whole plant	Methanol	<i>Bacillus cereus</i> , <i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Vibrio parahemolyticus</i> , <i>Vibrio mimicus</i> , <i>Candida albicans</i> , <i>Saccharomyces cerevisiae</i>	Rahman et al., 2008
<i>Amoora cucullata</i>	Leaves and stem	Methanol	<i>Escherichia coli</i> , <i>Vibrio cholerae</i> , <i>Salmonella typhi</i> , <i>Salmonella paratyphi</i> , <i>Shigella dysenteriae</i> , <i>Shigella flexneri</i> , <i>Pseudomonas spp.</i> , <i>Proteus spp.</i>	Ferdoushi et al., 2012
<i>Aphanamixis grandifolia</i>	Arial parts	Ethanol	<i>Staphylococcus aureus</i>	Yan-Jiao et al., 2013
<i>Aphanamixis polystachya</i>	Leaf	Petroleum ether, chloroform, ethyl acetate	<i>Bacillus subtilis</i> , <i>Bacillus megaterium</i> , <i>Sarcina lutea</i> , <i>Staphylococcus aureus</i> , <i>Salmonella typhi</i> , <i>Escherichia coli</i> , <i>Vibrio parahemolyticus</i> , <i>Shigella dysenteriae</i>	Ripa et al., 2012
<i>Azadirachta indica</i>	Fruit	Hexane, ethyl acetate, methanol	<i>Staphylococcus aureus</i> , <i>Shigella dysenteriae</i> , <i>Candida albicans</i>	Apu et al., 2013
	Leaf	Methanol	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i>	Mishra et al., 2013
	Leaf	Chloroform, Hexane, methanol	<i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Klebsiella pneumoniae</i> , <i>Aspergillus niger</i> , <i>Aspergillus fumigatus</i> , <i>Trichoderma viride</i> , <i>Cladosporium herbarum</i> , <i>Fusarium oxysporum</i>	Verma et al., 2013
	Leaf, bark, seed	Distilled water	<i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i> , <i>Proteus mirabilis</i> , <i>Enterococcus faecalis</i> , <i>Aspergillus fumigatus</i> , <i>Candida albicans</i>	Reddy et al., 2013
	Leaf, stem and root	Hot water and ethanol	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Proteus vulgaris</i> , <i>Bacillus subtilis</i>	Sharma et al., 2011
	Seed	Volatile oil	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i>	Sandanasamy et al., 2013
	Flower	Volatile oil	<i>Bacillus subtilis</i> , <i>Candida albicans</i> , <i>Microsporum gypseum</i>	Aromdee et al., 2005

Box 2 (Continued)				
Plant name	Part used	Extract	Microbes used	Reference
<i>Cabralea canjerana</i>	Leaves	Methanol	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Candida albicans</i>	Moreno et al., 2004
<i>Cedrela odorata</i>	Leaves	Ethanol, chloroform	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i> , <i>Aspergillus niger</i> , <i>Penicillium notatum</i> , <i>Mucor mucedo</i> , <i>Candida albicans</i>	Idu et al., 2013
	Bark	Volatile oil	<i>Bacillus cereus</i> , <i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i> , <i>Escherichia coli</i> , <i>Candida albicans</i> , <i>Aspergillus niger</i>	Villanueva et al., 2009
<i>Cedrela serrata</i>	Leaf and bark	Methanol	<i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i> , <i>Proteus mirabilis</i> , <i>Salmonella typhi</i> , <i>Escherichia coli</i> , <i>Citrobacter spp.</i>	Ahmad et al., 2013
<i>Chukrasia tabularis</i>	Whole plant	Methanol	<i>Escherichia coli</i>	Rahman et al., 2008
	Seed	Volatile oil	<i>Salmonella gallinarum</i> , <i>Klebsiella pneumonia</i>	Orishadipe et al., 2012
<i>Entandrophragma angolense</i>	Leaves	Methanol	<i>Staphylococcus aureus</i> subsp. <i>Aureus</i> , <i>Escherichia coli</i> , <i>Candida albicans</i>	Moreno et al., 2004
<i>Guarea macrophylla</i>	Stem bark	Methanol, ethanol, water, chloroform, pet ether	<i>Escherichia coli</i> , <i>Salmonella typhi</i>	Adebayo and Osman, 2012
<i>Melia azedarach</i>	Leaves, flowers and fruit-seed	Methanol	<i>Pseudomonas syringae</i> pv. <i>syringae</i> , <i>Xanthomonas campestris</i> pv. <i>campestris</i> , <i>Rathayibacter tritici</i> , <i>Escherichia coli</i>	Neycee et al., 2012
	Leaf	Methanol, ethanol, petroleum ether and water	<i>Bacillus cereus</i> , <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Aspergillus niger</i> , <i>Aspergillus flavus</i> , <i>Fusarium oxysporum</i> , <i>Rhizopus stolonifer</i>	Sen and Batra, 2012
	Leaves	Petrol, benzene, ethyl acetate, methanol, aqueous	<i>Staphylococcus aureus</i> , <i>Staphylococcus epidermidis</i> , <i>Enterococcus faecalis</i> , <i>Bacillus subtilis</i> , <i>Escherichia coli</i> , <i>Edwardsiella tarda</i> , <i>Klebsiella pneumonia</i> , <i>Proteus mirabilis</i> , <i>P. vulgaris</i> , <i>Pseudomonas aeruginosa</i> , <i>Salmonella typhi</i> , <i>Shigella boydii</i> , <i>Shigella dysenteriae</i> , <i>Shigella flexneri</i> , <i>Plesiomonas shigelloides</i> .	Khan et al., 2011
<i>Melia dubia</i>	Bark	Petroleum ether, ethyl acetate, ethanol and water	<i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Candida albicans</i> , <i>Aspergillus flavus</i>	Cinu and Sarma, 1999
<i>Munronia pumila</i>	Stem	Hexane, dichloromethane, methanol	<i>Saccharomyces cerevisiae</i> , <i>Escherichia coli</i> , <i>Micrococcus luteus</i> , <i>Bacillus subtilis</i> , <i>Bacillus cereus</i>	Jayasinghe et al., 2002
<i>Naragamia alata</i>	Leaf, stem and root	Hot water and ethanol	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Proteus vulgaris</i> , <i>Bacillus subtilis</i>	Sharma et al., 2011
<i>Sandoricum indicum</i>	Root	Distilled water, ethanol	<i>Streptococcus pyogenes</i> NRPC 101	Limsuwan and Voravuthikunchai, 2013
<i>Soymida febrifuga</i>	Leaf	Butanol	<i>Bacillus subtilis</i> , <i>Escherichia coli</i> , <i>Klebsiella pneumonia</i> , <i>Proteus vulgaris</i> , <i>Staphylococcus aureus</i>	Riazunnisa et al., 2013
<i>Swietenia macrophylla</i>	Seed	Volatile oil	<i>Staphylococcus aureus</i> , <i>Salmonella typhimurium</i> , <i>Pseudomonas aeruginosa</i>	Suliman et al., 2013
	Leaf	Ether, chloroform, ethanol and water	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i> , <i>Candida albicans</i> , <i>Aspergillus flavus</i> , <i>Aspergillus niger</i> , <i>Trichophyton mentagrophytes</i>	Ayyappadhas et al., 2012
	Wood Leaf, stem and root	Hexane Hot water and ethanol	<i>Aspergillus flavus</i> , <i>A. niger</i> <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Proteus vulgaris</i> , <i>Bacillus subtilis</i>	Malairajan et al., 2012 Sharma et al., 2011
<i>Toona ciliata</i>	Leaf	Methanol	<i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i> , <i>Bacillus subtilis</i> , <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Proteus vulgaris</i> , <i>Klebsiella pneumoniae</i> , <i>Pseudomonas aeruginosa</i> , <i>Proteus mirabilis</i> , <i>Aspergillus fumigatus</i> , <i>Candida albicans</i>	Chiranjib et al., 2011
	Aerial parts Leaf flower	Ethanol Petroleum ether, chloroform, ethyl acetate and methanol	<i>Staphylococcus aureus</i> , <i>Staphylococcus epidermidis</i> , <i>Klebsiella pneumonia</i> , <i>Proteus mirabilis</i> , <i>Pseudomonas aeruginosa</i> , <i>Salmonella typhimurium</i> , <i>Erwinia carotovora</i> , <i>Xanthomonas axonopodis</i> pv. <i>malvacearum</i> , <i>Xanthomonas campestris</i> pv. <i>vesicatoria</i> , <i>Xanthomonas oryzae</i> , <i>Candida albicans</i> , <i>Microsporum canis</i>	Yan-Jiao et al., 2013 Kavitha and Satis, 2013
	Heartwood	Hexane	<i>Staphylococcus aureus</i> , <i>Staphylococcus epidermidis</i> , <i>Bacillus cereus</i> , <i>Micrococcus luteus</i> , <i>Candida albicans</i> , <i>Aspergillus niger</i>	Malairajan et al., 2012
<i>Toona sinensis</i>	Leaves	Essential oil	<i>Bacillus subtilis</i> , <i>Escherichia coli</i> , <i>Pencillium citrinum</i> , <i>Colletotrichum gloeosporioides</i>	Jie et al., 2008; Chen et al., 2014
<i>Trichilia clausenii</i>	Bark	Methanol	<i>Alternaria alternata</i>	Carvalho et al., 2011
	Bark	Methanol	<i>Alternaria alternate</i>	Carvalho et al., 2011

Box 2 (Continued)

Plant name	Part used	Extract	Microbes used	Reference
<i>Trichilia lepidota</i> <i>Walsura robusta</i>	Leaves Leaf and branch	Methanol Distilled water and butanol	<i>Streptococcus pyogenes</i> NPRC 101	Moreno et al., 2004 Limsuwan and Voravuthikunchai, 2013
<i>Walsura trifoliata</i>	Bark	Methanol, distilled water, petroleum ether, benzene	<i>Bacillus subtilis</i> , <i>B. licheniformis</i> , <i>B. coagulans</i> , <i>B. cereus</i> , <i>Staphylococcus aureus</i> , <i>S. epidermidis</i> , <i>S. griseus</i> , <i>Escherichia coli</i> , <i>Proteus vulgaris</i> , <i>Pseudomonas fluorescens</i> , <i>Aspergillus niger</i> , <i>A. flavus</i> , <i>Candida albicans</i> , <i>Pencillium chrysogenum</i>	Murthy and Nagamani, 2008
<i>Xylocarpus granatum</i>	Pericarp, seed	Distilled water, ethanol	<i>Streptococcus pyogenes</i> NPRC 101	Limsuwan and Voravuthikunchai, 2013
	Bark	Methanol	<i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> , <i>Proteus vulgaris</i>	Shahid-Ud-Daula and Basher, 2009
	Leaf, cuticle, stem	Methanol, hexane	<i>Vibrio alginolyticus</i> , <i>Edwardsiella tarda</i>	Choudhury et al., 2005
<i>Xylocarpus mekongensis</i>	Bark	Methanol, ethyl acetate, chloroform	<i>Staphylococcus aureas</i> , <i>Vibrio cholera</i> , <i>Shigella boydii</i> , <i>Shigella flexneri</i> , <i>Salmonella typhi</i> , <i>S. paratyphi</i>	Arif et al., 2013
	Leaf stem	Methanol, chloroform	<i>Staphylococcus aureus</i> , <i>Pseudomonas putida</i> , <i>Escherichia coli</i> , <i>Bacillus polymyxa</i> , <i>Klebsiella sp.</i> , <i>Aspergillus fumigatus</i> , <i>A. niger</i>	Sahoo et al., 2013

antibacterial activity. Another interesting feature reported was inhibitory action of seed and leaf extracts of *Azadirachta indica* on fungi such as *Candida albicans*, *C. tropicalis*, *Neisseria gonorrhoeae* and the multi drug resistant *Staphylococcus aureus* (Talwar et al., 1997). Jayasinghe et al. (2002) screened Srilankan Meliaceae plants for antibacterial and antifungal activity.

Triterpenoids are an important group of constitutive defense substances present at sufficient concentrations to ward off potential plant pathogenic fungi (Grayer and Harborne, 1994). Triterpenoids from the family Meliaceae, in particular, are highly diversified in structure and have been extensively studied for their insect antifeedant and growth regulating activities (Champagne et al., 1992). Extracts from seeds of the neem tree *Azadirachta indica* containing triterpenoidal compounds are known to be effective against plant pathogenic fungi (Khan et al., 1974; Singh et al., 1980; Locke, 1995; Coventry and Allan, 1996; Govindachari et al., 1998; Steinhauer, 1999). Antifungal triterpenoids of the Meliaceae include four meliacins from *Chisocheton paniculatus* (Bordoloi et al., 1993) and nimonol and isomeldenin from *Azadirachta indica* (Suresh et al., 1997).

A number of limonoids have been reported from the genus *Swietenia* with structures assigned on the basis of spectral data (Kadota et al., 1990). Seven limonoids from methanolic extract of the seeds of *Swietenia mahogani* were isolated by Govindachari et al. (1999b). Triterpenoids (B,D-seco limonoids) from *S. mahogani* and *Khaya senegalensis* were evaluated for their antifungal activities (Govindachari et al., 1999b). Methyl angolenate and luteolin-7-O-glucoside obtained from ethyl acetate extracts of *Soymida febrifuga* root callus had an antibacterial effect against *Bacillus subtilis* and *Salmonella typhimurium*, respectively. In addition to that methyl angolenate had an anti-fungal activity against *Aspergillus niger* while luteolin-7-O-glucoside inhibited *Alternaria alternata* (Chiruvella et al., 2007).

Conclusion

Here we compiled the phytochemical and antimicrobial studies in taxa belong to the most important medicinal family Meliaceae, which might be effective in controlling infectious diseases. Nonetheless, the effectiveness of these phytochemicals needs to be validated *in vivo* for further investigation. Among the Meliaceae members, the genus *Aglaia*, *Azadirachta*, *Dysoxylum*, *Swietenia*, *Trichilia* have been more explored for the phytochemical screening

where as *Azadirachta*, *Swietenia*, *Trichilia* have been more explored for their antimicrobial properties. Our critical analysis of published research data shows that most of the antimicrobial screening was carried out using plant crude extracts which is not much useful for further drug development. As these extracts contain many compounds along with the active compounds may cause side or toxic effects. Hence future research should be focused on the isolation and identification of active compounds with antimicrobial activity rather than simply screening the plant crude extracts. In addition research should take in depth studies to know the mechanism of action of drug so that it is beneficial for drug discovery and development. This review stands as a readymade map for phytochemical constituents and antimicrobial activities of Meliaceae family for the future researchers dealing with Meliaceae members.

Author contributions

VP, KKC, AM drafted the text, structures and charts, KKC, AM, GRG made all the alignments, corrections and proof reading to the script, CT helped in tabulating and reference management. All authors contributed to analysis and interpretation if data for the review. All authors participated in revising the article.

Conflicts of interest

The authors declare no conflicts of interest.

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