Chapter 2

Structural diversity of secondary metabolites in *Garcinia* species

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Abstract

Plants of the genus *Garcinia* produce structurally diverse secondary metabolites such as biflavonoids, xanthones, benzophenones, flavonoids, biphenyls, acyl phloroglucinols, depsidones and terpenoids. The rich diversity in chemical structures made the genus *Garcinia* attractive for the phytochemists. In addition, several industrial sectors such as cosmetic, food, pharmaceutics, neutraceutics and paints are centered around the genus. The genus is represented by more than 250 species, among which nearly 120 species were subjected to phytochemical investigation. A review of the structural diversity of secondary metabolites of *Garcinia* species revealed that xanthones are the important class of secondary metabolites, distributed in 74 *Garcinia* species, followed by benzophenones in 50 species and biflavonoids in 45 species. Biphenyls, acyl phloroglucinols, depsidones and flavonoids are some other interesting group of phenolic compounds in *Garcinia* species. The present chapter enlists the major phenolic compounds reported from *Garcinia* species.

Keywords: *Garcinia*, Secondary metabolites, Xanthones, Biflavonoids, Benzophenones

Introduction

Plants continue to be an important source of diverse chemical structures with broad utilities in several fields like medicines, cosmetics, food, neutraceutics and pesticides. Despite the availability of alternative synthetic substituents, there has been an increasing awareness worldwide towards the use of phytochemicals and other plant derived products. The ever increasing demand for phytochemicals can be attributed to their diverse and complex chemical structures that are difficult to replicate in the laboratory, greater number of chiral centres and increased steric complexity compared to synthetic compounds (Croteau *et al*., 2000, Hostettman and Marston**,** 2002).

The genus *Garcinia* is well known for the value added products such as essential oils, fats, resins and colouring materials. Gamboge, the yellow colouring pigment, is a well known product from *Garcinia* species. Fruits of some *Garcinia* species are rich source of red pigments in the plant kingdom. *Garcinia* fruits are the source for a natural diet ingredient (-) hydroxycitric acid (HCA), which is an anti-obesity compound (Hemshekhar, *et al*., 2011, Parthasarathy, *et al.,*2013).

Recently, *Garcinia* species have received considerable attention worldwide from scientific as well as industrial sectors and several novel structures, bioactivities and potential utilities have been reported. Several industrial sectors like pharmaceutical, nutraceutical, paint and food additives were centred around this potential group of trees (Hemshekhar, *et al*., 2011, Magadula and Mbwambo 2014). In south India, *G. gummi-gutta* and *G. indica* were cultivated for commercial extraction of a variety of products such as bioactive acids, nutraceuticals, fats and condiments. In USA alone, mangosteen based beverages had a turnover of more than $200 million in 2008.

The genus *Garcinia* is represented by 250 species in the pantropical region, with high species richness in South East Asia. In India, 43 species and 5 varieties of the genus are reported, of which 37 species and 4 varieties occur in wild naturally, while the rest were introduced into cultivation. Nine *Garcinia* species were reported to occure naturally in the Western ghtas, of which 7 are endemic to the region (Sabu *et al*., 2013, Sarma *et al.* 2016). Of the nearly 250 species reported from world over, nearly 120 species were subjected to phytochemical investigation. Though several monographs and reviews on *Garcinia* species have appeared, a compilation of the phytochemistry of the *Garcinia* species has seldom been attempted (Obolskiy *et al*., 2009). Venkataraman (1973) has reviewed the chemistry of pigments from *Garcinia* species. A recent review on phytochemistry of *Garcinia* species in Africa revealed that out of the 80 *Garcinia* species reported in Africa, only 21 species have been investigated phytochemicaly (Magadula and Mbwambo 2014). Literature review revealed that out of the 9 *Garcinia* species reported from the Western Ghats, only 4 species have been studied in detail for their phytochemicals (Pandey *et al*., 2015, Anu Aravind *et al*., 2015).

Garcinia species are reported as rich depository of structurally diverse secondary metabolites such as xanthones, benzophenones and biflavonoids, in addition to flavonoids, biphenyls, acyl phloroglucinols, depsidones and triterpenoids as minor constituents. Volatile mono and sesqui terpenoids, and phenyl proapnoids were also reported from *Garcinia* species. Present chapter review the diversity of phytochemicals, especially the phenolic compounds, reported from *Garcinia* species worldover.

1. Xanthones

Xanthones, with two aromatic rings linked via carbonyl and ether linkages, are a group of secondary metabolites originated biosynthetically by condensation of acetate and shikimate derived moieties. Xanthones can be considered as regioselectively cyclized benzophenone derivatives.The mixed biogenetic origin of xanthone necessitates that the carbons be numbered according to biosynthetic convention (**Figure 1**). Carbons 1-4 were assigned to the acetate derived ring A, while the carbons 5-8 to the shikimate derived ring B (Gottlieb, 1968, Bennett and Lee, 1989).

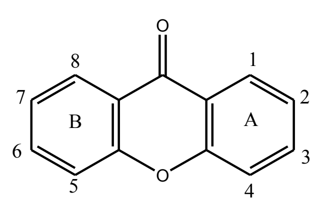


Figure 1. Numbering in typical xanthone structure

Xanthones are limited in distribution to a few plant families such as Clusiaceae, Gentianaceae, Moraceae and Polygalaceae and several reviews on xanthones have been published (Afsal and Al Hassan, 1980, Sultanbawa, 1980; Bennet and Lee, 1989, Peres *et al.,* 2000, Chantarasriwong *et al*., 2010, Anantachoke *et al.,* 2012). *Garcinia* species are important sources of xanthones and literature review revealed that 74 *Garcinia* species, comprising more than half of all the *Garcinia* species studied so far, were reported to contain xanthones (**Table 1**). Among different *Garcinia* species, *G. mangostana* has been studied extensively, and reported to conatin the highest number of xanthones followed by *G. cowa*.

The xanthones isolated can be classified into five major groups: simple oxygenated xanthones, prenylated xanthones, xanthone glycosides, xanthonolignoids, and miscellaneous xanthones (Mandal *et al.,*1992). Simple oxygenated xanthones are subdivided according to the degree of oxygenation into mono-, di-, tri-, tetra-, penta- and hexa-oxygenated xanthones. Isopentenyl and geranyl substituted xanthones are the common types in the genus *Garcinia.* The isopentenyl group may be modified by terminal cyclisation with ortho hydroxyl group to give a chromene system as in the case of jacareubin (Bennet and Lee, 1989). In some cases, the geranyl group may undergo cyclisation leading to structurally intriguing class of secondary metabolites known as caged xanthones, where C ring has been converted into an unusual 4-oxa-tricyclo[4.3.1.03,7]dec-8-en-2-one ring (caged) scaffold (Yang, *et al*., 2012). Caged xanthones like gambogic acid and morellin were mainly reported from the genus *Garcinia* (**Figure 2**). Some of the bixanthones reported from *Garcinia* species are bigarcinenone (*G. xanthochymus*), garcilivins (*G. livingstonei*), garciobioxanthone (*G. oblongifolia*) and griffipavixanthone (*G. griffithi*). Bennet and Lee (1989**)** have pointed that 1,3,5,6 tetraoxygenated xanthones were reported only from African *Garcinia* species and not from any of the Asian *Garcinia* species.

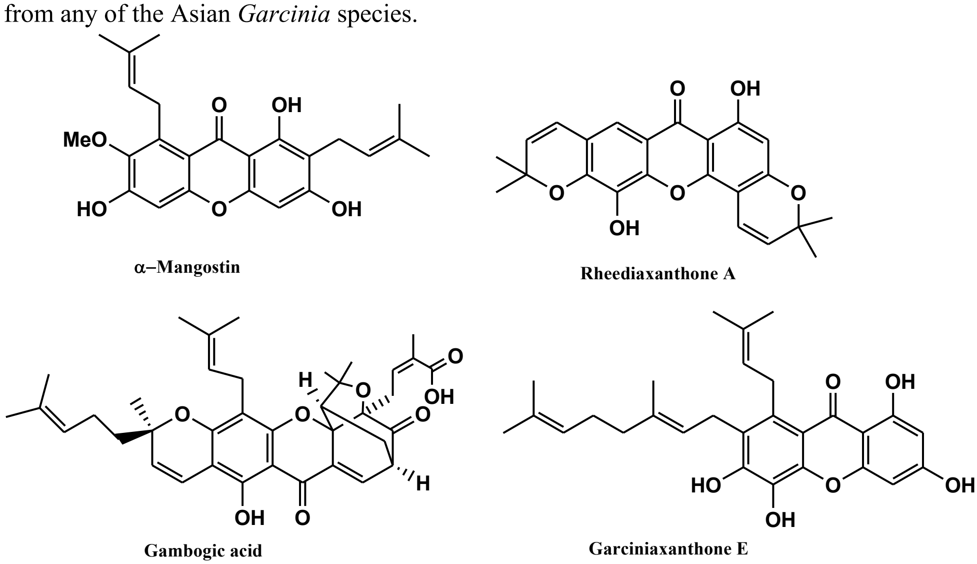


Figure 2. Prenylated xanthone (α-mangostin), xanthone with terminal cyclisation and ortho-hydroxyl group (rheediaxanthone), geranyl substituted xanthone (garciniaxanthone E) and caged xanthone (gambogic acid)

Though complex in structure, Yang, *et al.* (2012) reported the rapid characterization of caged xanthones in the resin of *G. hanburyi* using multiple mass spectrometric scanning modes. The hyphenated approach combining centrifugal partition chromatography (CPC), high-performance liquid chromatography (HPLC) with diode-array detection (DAD) and mass spectrometry (MS) was applied to the fractionation and purification of xanthones from *G. mangostana* fruits, where CPC efficiently separated the metabolites while the structural information was obtained from mass spectral data (Michel *et al*., 2012). A simple UV-Vis spectrophotometry method has been reported for the estimation of xanthones in *G. mangostana*, using α-mangostin, that has absorption maxima at 243.4 and 316.4 nm, as the reference compound (Aisha *et al*., 2013).

Xanthones are attributed with remarkable bioactivities such as antibacterial, antifungal, antiviral, antioxidant, anti-inflammatory and cytotoxic to cancer cells (Chin *et al*., 2008; Peres *et al.,*2000). The xanthone α-mangostin, attributed with antioxidant and anticarcinogenic properties, is one of the active ingredients of nutritional supplements derived from mangosteen (*G. mangostana*) fruits (Gutierrez-Orozco and Failla, 2013). Most of the caged xanthones are reported with potential antitumor activity, with gambogic acid being the best representative and most studied member of this group of compounds (Han and Xu, 2009, Chantarasriwong *et al*., 2010, Xu *et al*., 2015). Desoxymorellin, morellic acid, gambogic acid, forbesione, hanburin, and dihydroisomorellin were reported to exhibit anti-HIV-1 activity (Reutrakul *et al.,* 2007). 7-O-methylgarcinone E, cowanin, cowanol, cowaxanthone, and β-mangostin were found to possess *in vitro* antimalarial activity against *Plasmodium falciparum* (Likhitwitayawuid *et al.,*1998). α- and β-Mangostins, and garcinone B exhibited strong inhibitory effect against *Mycobacterium tuberculosis*. Structure activity relationship (SAR) studies showed that tri- and tetra-oxygenated xanthones with di-C5 units or with a C5 and a modified C5 groups are essential for higher activities (Suksamrarn *et al.,* 2003).

Table 1. Xanthones reported from *Garcinia* species

Sl. No.	*Garcinia* species	Plant part	Xanthones	Reference
1	*G. afzelii*	Stem bark	Afzeliixanthones A and B	Waffo *et al*., 2006
2	*G. amplexicaulis*	Stem bark	Cudraxanthone G, 1,3,5-trihydroxy-4-prenylxanthone, nigrolineaxanthone F, and 1,3,7-trihydroxy-2-prenylxanthone	Lavaud *et al*, 2015
3	*G. assigu*	Stem bark	Assiguxanthone A and B, dulxanthone A-D, and latisxanthone A-D	Ito *et al*., 1997
4	*G. atroviridis*	Stem bark	Garcinexanthone G	Tan *et al*.,2016
5	*G. benthamiana*	Leaf	1,3,6,7-Tetrahydroxy xanthone	Amelia *et al*., 2015
		Stem bark	Benthamianone	See *et al*., 2016
6	*G. bracteata*	Leaf	Garcibracteatone, xerophenone C, 5-O-methylxanthone V_1, nemorosonol, and 10-O-methyl macluraxanthone	Thoison *et al*, 2005
		Bark	Neoisobractatins A and B, and bracteaxanthone I and II	Thoison *et al*, 2005

		Stem bark	1,4,5,6-Tetrahydroxy xanthone, bracteaxanthones III-VI, 1,4,6-trihydroxy-5-methoxy-7-prenylxanthone, 1,4,5,6-tetrahydroxy-7,8-di(3-methylbut-2-enyl)xanthone, 1,4,5,6-tetrahydroxy-7-prenylxanthone, 1,4,5-trihydroxyxanthone, 1,4-dihydroxy-5,6-dimethoxyxanthone, garciniaxanthone H, symphoxanthone, 1-O-methylsymphoxanthone, morusignin I, garcinexanthone B, 6-deoxyjacareubin, 1,3,5,6-tetrahydroxyxanthone, 1,3,6,7-tetrahydroxyxanthone, 1,5-dihydroxy-3-methoxyxanthone, 1,5-dihydroxy-3,8-dimethoxyxanthone, 1,7-dihydroxyxanthone, 1,2,5-trihydroxyxanthone, 2,6-dihy droxy-1,5-dimethoxyxanthone, 2,5-dihy droxy-1-methoxyxanthone, 1,2, 5-trihydroxy-6-methoxyxanthone, 12β-hydroxy- D-garcigerrin A, 3-hydroxy-1, 5-dimethoxyxanthone, garciniaxanthone E, 6-deoxyisojacareubin, and garciduol A	Niu *et al*, 2012
		Twig	Neobractatin	Na *et al*, 2010
7	*G. brasiliensis*	Epicarp	1,3,6,7-Tetrahydroxyxanthone	Gontijo *et al*, 2012
8	*G. buchananii*	Heartwood	Buchanaxanthone, 1,5,6-trihydroxyxanthone and 1,5-dihydroxyxanthone	Jackson *et al*., 1968a
9	*G. cantleyana*	Twig	1,3,6-Trihydroxy-5 -methoxy-7-(30-methyl-20-oxo-but-30-enyl)xanthone, 1,3,5-tri- hydroxyxanthone, 1,3,8-trihydroxyxanthone, 2,4,7-trihydroxy xanthone, and 1,3,5,7-tetrahydroxyx anthone	Jantan and Saputri, 2012
		Leaf and trunk bark	Cantleyanone A, 7-hydroxyforbesione, 4-(1,1-dimethylprop-2-enyl)-1,3,5,8-tetrahydroxy xanthone, and cantleyanones B-D	Shadid *et al*, 2007
10	*G. chapelieri*	Bark	Chapexanthone A and B	Rambeloson *et al*, 2014
11	*G. cochinchinensis*	Pericarp	Dulxanthone A, 1,3,5-trihydroxy-6-methoxy-7-(3-methylbut-2-enyl)xanthone, 1,3,5-trihy- droxy-13,13-dimethyl-2H-pyran[7,6-b]xanthen-9-one, and 1,3-dihydroxy-5,6-dimethoxy-7-(3-methyl- but-2-enyl)xanthone	Nguyen *et al*, 2011
12	*G. costata*	Branch	Costatin	Nuangnaowarat *et al*.,2010
13	*G. cowa*	Leaf	Cambogic acid and mangostin	Pandey *et al*., 2015
		Stem bark	Garciniacowol, garciniacowone, parvifoliol F, α-mangostin, β-mangostin , cowaxanthone, norcowanin, cowanin, cowanol, cowagarcinone B, cowagarcinone D, cowagarcinone E, fuscaxanthone A, fuscaxanthone C, 6-O-methylmangostanin, cowaxanthone D, and 1,7-dihydroxyxanthone	Siridechakorn *et al*, 2012
			2-(3-Methyl-2-butenyl)-1,5,6-trihydroxy-3-methoxy-4- (1,1-dimethyl-2-propenyl)-9H-xanthen-9-one, and rubraxanthone	Wahyuni *et al*, 2004

			7-O-Methyl garcinone E	Likhitwitayawuid *et al*.,1997
			Cowanin, cowanol, norcowanin, cowaxanthone, and 1,3,6-trihydroxy-7-methyl-2,5-bis(preny1) xanthone	Thongtheerapar p *et al*., 1994
			1,3.6-Trihydroxy-7-methoxy-8-(3,7-dimethyl)-2,6-octadieny xanthone	Lee *et al*.,1977
		Fruit	Cowaxanthones A-E, l,6-dihydroxy-3,7-dimethoxy-2-(3-methyl-2- butenyl)xanthone, fuscaxanthone C, 7-O-methylgarcinone E, β-mangostin, mangostanin, 6-O-methyl mangostanin, α-mangostin, and cowaxanthone	Panthong *et al*., 2006
			Garcicowanones A and B, 9-hydroxy calabaxanthone, β-mangostin, fuscaxanthone A, cowaxanthone D, cowanin, α-mangostin, cowagarcinone E, and rubraxanthone	Auranwiwat *et al*., 2014
			Garciniacowones A-E, cowaxanthone,1 3-O-methylmangostenone D, garcinianone A, and garcinianone B	Sriyatep *et al*., 2015
		Twig	Cowaxanthone F and 1,6-dihydroxyxanthone	Panthong *et al*., 2009
			β-Mangostin, cowanol, cowanin, norcowanin and 3,6-di-O-methyl-γ-mangostin	Cheenpracha *et al*., 2011
		Flower	Garciniacowones D and E, mangostanin, 6-O-methylmangostanin, fuscaxanthone A, fuscaxanthone C, 7-O-methylgarcinone E, cowaxanthone D, α-mangostin, β-mangostin, 3,6-di-O-methyl-γ-mangostin, and rubraxanthone	Sriyatep *et al.,* 2015
		Root	Kaennacowanols A-C	Kaennakam *et al.,* 2015
		Leaf	Cowaxanthones G and H, 1,3,5-trihydroxy-6′,6′-dimethyl-2*H*-pyrano(2′,3′:6,7)xanthone, 1,5,6-trihydroxy-2-prenyl-6′,6′-dimethyl-2*H*-pyrano(2′,3′:3,4)xanthone, isojacareubin, guttiferone F, jacareubin, xanthone V1, isoprenylxanthone, garcinexanthone C, xanthone V1a, 1,3,5-trihydroxyxanthone, ugaxanthone, 1,5,6-trihydroxy-3-methoxyxanthone, 1,3,7-trihydroxy xanthone, and 1,4,5-trihydroxyxanthone	Xia *et al.,* 2015
		Latex	Cowagarcinone A-E, cowaxanthone, cowanin, cowanol, 1,3,6-trihydroxy-7-methoxy-2,5-bis(3-methyl-2- butenyl)xanthone, mangostinone, and fucaxanthone A	Mahabusarakam *et al.,* 2005
14	*G. cylindrocarpa*	Stem bark	Cylindroxanthones A-C	Sukandar *et al.,* 2016
15	*G. cuneifolia*	Stem bark	Cuneifolin	Ee *et al*., 2003
16	*G. densivenia*	Stem bark	Pyranojacareubin	Waterman and Crichton, 1980
17	*G. dulcis*	Leaf	Dulxanthone E	Kosela *et al.,* 1999
		Fruit	Dulcisxanthone A, l,6-dihydroxy-3,7-dimethoxy-2-	Deachathai *et*

			(3-methyl-2-butenyl)xanthone, cowaxanthone, cowanin, l,7-dihydroxy-3-methoxy-2-(3- methyl-2-butenyl)xanthone, 1,5,8-trihydroxy-3-methoxy-2-(3-methyl-2- butenyl) xanthone, BR-xanthone A, mangostin, 6,8,12-trihydroxy-7-(3-methyl-2-butenyl)- 2-methyl-2-(4-methyl-3-pentenyl)pyrano(20,30:7, 8)xan thone, garcinone D, mangostenol, tovophyllin A, and cratoxylone	*al.,* 2005
18	*G. echinocarpa*	Bark and wood	1,5-Dihydroxyxanthone and 1,3,6,7-tetrahydroxy xanthone	Bandaranayake *et al.,* 1975
		Leaf	Cambogic acid and mangostin acid	Pandey *et al.,* 2015
19	*G. edulis*	Root bark	1,4,6-Trihydroxy-3-methoxy-2-(3-methyl-2-butenyl)-5-(1,1- dimethyl-prop-2-enyl) xanthone and forbexanthone	Magadula*,* 2010
20	*G. esculenta*	Twig	1,3,5,7-Tetrahydroxy-8-isoprenylxanthone	Zhang *et al.,* 2015
21	*G. eugenifolia*	Twig	5,9-Dihydroxy-8-methoxy-2,2-dimethyl -7-(3-methylbut-2-enyl)pyrano[3,2-b]xanthen-6(2H)-one	Mian *et al.,* 2010
		Heart wood	Euxanthone, gentisin, 1,4,7-trihydroxy-3-methoxyxanthone, 1,5,6-trihydroxyxanthone, and 1,6,7-trihydroxyxanthone	Jackson *et al.*, 1969
22	*G. forbesii*	Branch and twig	Forbexanthone, pyranojacareubin, and 1,3,7-trihydroxy-2-(3-methylbut-2-enyl)-xanthone	Harrison *et al.,*1993
23	*G. fusca*	Root	Fuscaxanthone I, β-mangostin, fuscaxanthone A, cowanin, cowaxanthone, α-mangostin, cowanol, isojacareubin, fuscaxanthone G, and 1,3,5,6-tetrahydroxyxanthone	Nontakham *et al.,* 2014
		Stem bark	Fuscaxanthone A-H, cowaxanthone, β-mangostin, cowanin, rubraxanthone, α-mangostin, cowanol, norcowanin, 7-O-methylgarcinone, and garbogiol	Ito *et al.,* 2003a
24	*G. gaudichaudii*	Bark	Gaudispirolactone	Wu *et al.,* 2001
			Gaudichaudiic acids F , G , H and I	Xu *et al.,* 2000
		Leaf	Gaudichaudiones A- H, gaudichaudiic acids A-E, morellic acid, and forbesione	Cao *et al.,* 1998
25	*G. griffithii*	Stem bark	1,5-Dihydroxy-3,6-dimethoxy-2,7-diprenylxanthone and 1,6- dihydroxyxanthone	Elfita *et al.,* 2009
			1,7-dihydroxyxanthone, 1,3,6,7-tetrahydroxyxanthone and 1,3,5,6-tetrahydroxy xanthone	Nguyen *et al.,* 2005
			Griffipavixanthone	Xu *et al*., 1998
		Leaf	1,3,5,6-Tetrahydroxy-7-(3-methylbut-2-enyl)xanthone and rubraxanthone	Alkadi *et al.,* 2013
26	*G. gummi-gutta* (*G. cambogia*)	Leaf	Cambogic acid and mangostin	Pandey *et al.,* 2015
		Root	Garbogiol	Iinuma *et al*., 1998 Semwal *et al.,* 2015
		Bark	Rheediaxanthone	Semwal *et al.,* 2015

		Fruit	Oxy-guttiferone K , oxy-guttiferone K2 and oxy-guttiferone Oxy-guttiferones M, K, K2 and I	Masullo *et al*, 2010 and Semwal et al., 2015
27	*G. hanburyi*	Resin	Garcinolic acid, 10α-ethoxy-9,10-dihydromorellic acid, and 10α-ethoxy-9,10-dihydrogambogenic acid	Deng *et al.*, 2012
			Gambogic aldehyde	Wang *et al.*, 2008
			Forbesione, isomorellic acid, morellic acid, R-30-hydroxygambogic acid, S-30-hydroxygambogic acid, isogambogenic acid, gambogenic acid, R-isogambogic acid, S-isogambogic acid, R-gambogic acid, S-gambogic acid, desoxymorellin, isogambogenin and isomorellinol	Zhou *et al.*, 2008a
			Forbesione, forbesionic acid, isoforbesionic acid, desoxygaudichaudione A, gaudichaudionol, isogaudichaudionol, epoxylgaudichaudione A, gaudichaudione A, isogaudichaudione A, gaudichaudionic acid, isogaudichaudionic acid, desoxymorellin, morellinol, isomorellinol, morellin isomorellin, morellic acid, isomorellic acid, desoxygambogenin, gambogeninol, isogambogeninol, gambogenin, isogambogenin, gambogenic acid, isogambogenic acid, dihydrodesoxygambogenin S-gambogic acid,R-gambogic acid, S-30-hydroxygambogic acid, R-30-hydroxygambogic acid, R tetrahydrogambogic acid, and hanburin R	Yang *et al.*, 2012
		Latex	Gambogin, morellin dimethyl acetal, isomoreollin B, moreollic acid, gambogenic acid, gambogenin, isogambogenin, desoxygambogenin, gambogenin dimethyl acetal, gambogellic acid, hanburin, gambogic acid, isomorellin, morellic acid, and desoxymorellin	Asano *et al.*, 1996
			Isogambogenic acid, desoxymorellinin, 10-methoxygambogenic acid, 10-methoxygambogic Acid, and 10-ethoxy gambogic acid	Feng *et al.*, 2007
28	*G. hombroniana*	Leaf	Cambogic acid and mangostin	Pandey *et al.*, 2015
		Twig	Garcihombronones A-D	Klaiklay *et al.*, 2013
		Bark	1,3,6-Trihydroxy-7-methoxy-2,8-(3-methyl- 2-butenyl) xanthone	Jamila *et al.*, 2014
			1,3,6,7-Tetrahydroxy xanthone	Jamila *et al.*, 2014a
29	*G. indica*	Leaf	Cambogic acid and mangostin	Pandey *et al.*, 2015
30	*G. linii*	Root	1,5-Dihydroxy-6-methoxy xanthone and 1,7-dihydroxy-3-methoxy xanthone	Chen *et al.*, 2006
31	*G. lancilimba*	Stem bark	1,5,6-Trihydroxy-6',6'-dimethyl-2H-pyrano(2',3':3,4)-2-(3-methylbut-2-enyl) xanthone	Yang *et al.*,2007

			and 1,6,7-trihydroxy-6',6'-dimethyl-2H-pyrano(2',3':3,2)-4-(3-methylbut-2-enyl) xanthone	
32	*G. lateriflora*	Stem bark	Isomoreollic acid, isogaudichaudiic acid, isogaudichaudiic acid E, 11,12-dihydro -12-hydroxy morellic acid, and isogaudichaudiic acid B	Ren *et al.,* 2010
33	*G. livingstonei*	Root bark	1,4,5-Trihydroxy-3-(3-methylbut-2-enyl)-9H-xanthen-9-one, 1,4,5-Trimetkoxy-3-(3-methylbut-2-enyl)-9H-xanthen-9-one, 3,4-dihydro-6,1l-dihydroxy-2,2-dimethyl-pyrano[3,2-c]-xan-then-7(2H)-one, 6,11-dihydroxy-2,2-dimethyl-pyrano [3,2-c] xanthen-7(2H)-one, and 6,l l-dihydroxy-3-methyl-3-(4-methylpent-3-enyL)- 3H,7H-pyrano[2,3-c] xanthen-7-one	Sordat-Diserens *et al.,* 1992a
			Garcilivin A-C	Sordat-Diserens *et al.,* 1992
34	*G. lucida*	Stem bark	1,2-Dihydroxy xanthone and 1-hydroxy-2-methoxy xanthone	Momo *et al.*, 2011
35	*G. malaccensis*	Stem bark	α and β-Mangostins	Taher *et al.,* 2012
36	*G. mangostana*	Leaf	Cambogic acid and mangostin	Pandey *et al.,* 2015
			Gartanin	Sen *et al.,*1980
			1,5,8-Trihydroxy-3-methoxy-2[3- methyl-2-butenyl] xanthone, and 1,6-dlhydroxy-3- methoxy-2[3-methyl-2-butenyl]xanthone	Parveen and Khan,1988
		Pericarp	Mangostinone, α, β and γ-mangostins, gartanin, garcinone E, 1,5-dihydroxy-2-(3-methylbut- 2-enyl)-3-methoxy xanthone, and 1,7-dihydroxy-2-(3-methylbut-2-enyl)-3-methoxyxanthone	Asai *et al.,*1995
			1,3,7-Trihydroxy-2-(3-methyl-2-butenyl)-8-(3-hydroxy-3-methylbutyl)-xanthone, 1,3,8-trihydroxy-2-(3-methyl-2-butenyl)-4-(3-hydroxy-3-methylbutanoyl)-xanthone, garcinones C and D, gartanin, xanthone I, and γ-mangostin	Xu *et al.,* 2014
			3-Hydroxy-6-methoxy-5'-isopropyl-4',5'-dihydrofuro [2',3' : 7, 8]-6'',6''-dimethyl-4'',5''-dihydropyrano[2'',3'' : 1,2]xanthone, and 1,6-dihydroxy-7-methoxy-8-(3-methylbut-3-enyl)-6',6'-dimethyl-4',5'-dihyd ropyrano[2'3'' : 3,2] xanthone	Zhao *et al.,* 2012
			Garcimangosxanthone A-C, α-mangostin, γ-mangostin, garcinone C and D, trapezifolixanthone, 8-deoxygartanin, gartanin, 2-(γ,γ-dimethylallyl)-1,7-dihydroxy-3-methoxyxanthone 1,5-dihydroxy-3-methoxy-2-prenylxanthone garcinone B, 9-hydroxycalabaxanthone, dulxanthone D and 1,3,7-trihydroxy-2-(3-methylbut-2-enyl)-xanthone and tevophyllin A	Zhang *et al.,* 2010a
			8-Hydroxycudraxanthone G, mangostingone [7-methoxy- 2-(3-methyl-2-butenyl)-8-(3-methyl-2-oxo-3-butenyl)-1,3,6-trihydroxyxanthone, cudraxanthone G, 8-deoxygartanin, garcimangosone B, garcinone D, garcinone E, gartanin, 1-	Jung *et al.,* 2006

			isomangostin, R-mangostin, γ-mangostin, mangostinone, smeathxanthone A, and tovophyllin A	
			Garcimangosxanthone F-G	Zhou *et al.*, 2015
			Garcimangosxanthone D-E	Zhou *et al.*, 2011
			1,3,6-Trihydroxy-2-(3-methylbut-2-enyl)-8-(3-formyloxy-3-methylbutyl)xanthone	Xu *et al.*, 2016
			3-Isomangostin, 8-desoxygartanin, gartanin, α-mangostin, 9-hydroxycalabaxanthone, and β-mangostin	Ji *et al.,* 2007
			3-Isomangostin, 8-desoxygartanin, gartanin, α-mangostin, 9-hydroxycalabaxanthone, and β-mangostin	Ji *et al.,* 2007
			Mangostin, Gartanin, ϒ-Mangostin, β-mangostin, 3-isomangostin, 3-isomangostin hydrate and 1-isomangostin hydrate	Mahabusakaram *et al.*, 1987
		Fruit	1,2-Dihydro-1,8,10-trihydroxy-2-(2-hydroxypropan-2-yl)-9-(3-methylbut-2-enyl)furo[3,2-a]xanthen-11-one, 6-deoxy-7-demethylmangostanin, 1,3,7-trihydroxy- 2,8-di-(3-methylbut-2-enyl)xanthone, mangostanin, and α-mangostin	Chin *et al.,* 2008
			3-Isomangostin, mangostanol, 8-deoxygartanin gartanin, α-mangostin, garcinone E, 9-hydroxy calabaxanthone, and γ-mangostin	Zarena and Sankar, 2009
			α-Mangostin, γ-mangotsin,gartanin,1-isomangostanin, garcinone E, and tilirosidea	Quan *et al.,* 2010
		Fruit hull	Garcinones A, B and C	Sen *et al.,* 1982
			Mangostenol, mangostenone A, mangostenone B, trapezifolixanthone, tovophyllin B, α and β-mangostins, garcinone B, mangostinone, and mangostanol	Suksamrarn *et al.,* 2002
			α and γ-Mangostin	Chen *et al.,* 2008
			BR-Xanthone A and B	Balasubramanian and Rajagopalan, 1988
			Mangostanol, α-mangostin, γ-mangostin, gartanin, 8-deoxygartnin, 5,9-dihydroxy-2,2-dimethyl-8-methoxy-7-(3- methylbut-2-enyl)-2H,6H-pyrano[3,2-b]xanthen-6-one, garcininone E, and 2-(γ,γ-dimethylallyl)-l,7-dihydroxy-3-methoxyxanthone	Chairungsrilerd *et al.,* 1996
			β-Mangostin, 9 hydroxy calabaxanthone, mangostanol, mangostenone F, allanxanthone E, α-mangostin, mangostingone, garcinone D, γ-mangostin, mangosenone G, cudraxanthone, 1,5,8-trihydroxy-3-methoxy-2-(3-methylbut-2-enyl)xanthone, 8- deoxygartanin, gartanin, smeathxanthone A, and 1,3,6-trihydroxy-7-	Ryu *et al.,* 2011

			methoxy-2-(3-methylbut-2-enyl)-8-(2-oxoethyl)-9H-xanthen-9-one	
			2,7-Di- 3-methylbut-2-enyl -1,3,8-trihydroxy-4-methyl xanthone and 2,8-di- 3-methylbut-2-enyl -7-carboxy-1,3-dihydroxyxanthone	Gopalakrishnan *et al.,* 2000
			1,3,6,7-Tetrahydroxy-2,8-(3- methyl-2-butenyl) xanthone and1,3,6-trihydroxy-7-methoxyl-2,8-(3-methyl-2- butenyl) xanthone	Yu *et al.,* 2007
			Garcimangosone A, garcimangosone B, and garcimangosone C	Huang *et al.,* 2001
			1,5-dihydroxy-2-(3-methyIbut-2-enyl)-3-methoxyxanthone and 1,7-dihydroxy-2-(3-methylbut-2-enyl)-3-methoxyxanthone	Sen *et al.,*1981
			Mangostin, BR-xanthone A, gartanin, β-mangostin γ-mangostin, and garcinone D	Gopalakrishnan *et al.,* 1997
			Gartanin, 8-deoxygartanin, normangostin, α-mangostin, and β-mangostin	Govindachari *et al.*, 1971
			Mangostin	Yates and Stout, 1958
		Seed case	β-Mangostin, 9-hydroxy calabaxanthone, mangostanone, α-mangostin, garcinone D, γ-mangostin, cudraxanthone, 8-deoxygartanin, gartanin, smeathxanthone A, and mangostenone F, G	Ryu *et al.,* 2010
		Heartwood	Mangoxanthone, dulxanthone D, 1,3,7-trihydroxy-2-meth- oxyxanthone, and 1,3,5-trihydroxy-13,13-dimethyl-2H-pyran[7,6-b]xanthen-9-one	Nguyen *et al.,* 2005
			α-Mangostin, β-mangostin, γ- mangostin, garciniafuran, 1-hydroxy-8-(2-hydroxy-3-methylbut-3-enyl)- 3,6,7-trimethoxy-2-(3-methylbut-2-enyl)-xanthone, 1,6-dihydroxy-2-(2-hydroxy-3-methylbut-3-enyl)- 3,7-dimethoxy-8-(3-methylbut-2-enyl)-xanthone, 1,6-dihydroxy-8-(2-hydroxy-3-methylbut-3-enyl)- 3,7-dimethoxy-2-(3-methylbut-2-enyl)-xanthone, 1-hydroxy-3,6,7-trimethoxy-2-(2-hydroxy-3- methylbut-3-enyl)-8-(3-methylbut-2-enyl)-xanthone, 1,3-dihydroxy-2-(2-hydroxy-3-methylbut-3-enyl)- 6,7-dimethoxy-8-(3-methylbut-2-enyl)-xanthone, mangostanin, (16E)-1,6-dihydroxy-8-(3-hydroxy-3-methylbut-1- enyl)-3,7-dimethoxy-2-(3-methylbut-2-enyl)-xanthone , 6-O-methylmangostanin, (16E)-1-hydroxy-3,6,7-trimethoxy-2-(3-methylbut- 2-enyl)-8-(3-hydroxy-3-methylbut-1-enyl)-xanthone, 1,6-dihydroxy-3,7-dimethoxy-2-(3-methylbut-2- enyl)-xanthone, 1-hydroxy-3,6,7-trimethoxy-2-(3-methylbut-2- enyl)-8-(2-oxo-3- methylbut-3-enyl)-xanthone, and 1-hydroxy-3,6,7-trimethoxy-2-(3-methylbut-2- enyl)-xanthone	Nilar and Harrison, 2002
		Aril	Mangostin, Calbaxanthone, Demethylcalbaxanthone, 2-(γ,γ-dimethylallyl)-l,7-dihydroxy-3- methoxyxanthone and 2,8-bis-(γ,γ-dimethylallyl)-l,3,7-trihydroxyxanthone	Mahabusakaram *et al.*, 1987

		Aril and pericarp	1,7-Dihydroxy-3-methoxy- 2-(3-methylbut-2-enyl)xanthone, γ-mangostin, 8-deoxygartanin 1,3,7-trihydroxy-2,8-di- (3-methylbut-2-enyl)xanthone, 1,3,7-trihydroxy-2,8-di- (3-methylbut-2- enyl)xanthon gartanin, α-mangostin, and garcinon E	Wittenauer *et al.,* 2012
		Stem and root	2,6-Dihydroxy-8-methoxy-5-(3- methylbut-2-enyl)-xanthone	Ee *et al*., 2006
		Stem	Mangosharin , (2,6-dihydroxy-8-methoxy-5-(3-methylbut-2-enyl)-xanthone), α -mangostin, β-mangostin, garcinone D, 1,6-dihydroxy-3,7-dimethoxy-2-(3-methylbut-2-enyl)-xanthone, mangostanol and 5,9-dihydroxy-8-methoxy-2,2-dimethyl-7-(3-methylbut-2-enyl)-2H,6H-pyrano-[3,2-b]-xanthene-6-one	Ee *et al*., 2006
		Stem bark	Mangaxanthone B, mangostanin, and mangostenol	See *et al.,* 2014
			11-Hydroxy-3-O-methyl-1-isomangostin,11-hydroxy-1-isomangostin, 11α-mangostanin, 3-isomangostin, α-mangostin, β-mangostin, garcinone D , 9 hydroxy calabaxanthone, 8-deoxygartanin, gartanin, and cratoxyxanthone	Han *et al.,* 2009
		Root bark	β-Mangostin, α-mangostin, garcinone-D, mangostanol, and gartanin	Ee *et al*.,2006
			Mangostin and β-mangostin	Govindhachari *et al*., 1971
		Latex	Mangostin and β-mangostin	Govindachari *et al*., 1971
37	*G. merguensis*	Bark	Merguenone, 1,5-dihydroxy-60-methyl-60-(4-methyl-3-pentenyl)- pyrano(20,30:3,2)-xanthone, subelliptenone H, 8-deoxygartanin, rheediaxanthone A, morusignin G, 6-deoxyjacareubin, 1,3,5-trihy-droxy-4,8-di(3-methylbut-2-enyl)-xanthone, rheediachromenoxanthone, and 6-deoxyisojacareubin	Nguyen *et al.,* 2003
		Twig	Merguensinone and 1,5,6- trihydroxy-2-prenyl-60,60-dimethyl-2H-pyrano(20,30:3,4)xanthone	Trisuwan *et al.,* 2013
		Wood	5-Farnesyltoxyloxanthone B, α-mangostin, rubraxanthone, and isocowanol	Kijjoa *et al.,* 2008
38	*G. morella*	Seed	Morellin	Rao 1937, Rao and Natarajan 1950 and Kartha *et al*., 1963
		Pericarp	Morellin	Karanjgaokar *et al.,* 1967
		Leaf	Cambogic acid and mangostin	Pandey *et al.,* 2015
39	*G. nervosa*	Stem bark	Nervosaxanthone	Ampofo and Waterman, 1986
40	*G. nobilis*	Stem bark	Caroxanthone, 4-prenyl-2-(3,7-dimethyl-2,6-octadienyl)-1,3,5,8-tetrahydroxyxanthone, smeathxanthone A, gartanin, euxanthone, 8-hydroxycudraxanthone G, and morusignin I	Fouotsa *et al.,*2012

41	*G. nigrolineata*	Leaf	Nigrolineaxanthones J-S	Rukachaisirikul *et al.,* 2003
		Stem bark	Nigrolineaxanthones A–I, 1,3,5-trihydroxy-4-(3-hydroxy-3-methylbutyl)xanthone, 1,3,7-trihydroxy-2-(3-hydroxy- 3-methylbutyl)xanthone, 6-deoxyjacreubin, morusignin C, 1,5-dihydroxy-6’,6’-dimethylpyrano[2’,3’:3,2] xanthone, and tovoxanthone	Rukachaisirikul *et al.,* 2003c
42	*G. nitida*	Stem bark	1,6-Dihydroxy-5-methoxy-6,6-dimethylpyrano[2',3':2,3]-xanthone, inophyllin B, osajaxanthone, 3-isomangostin, and rubraxanthone	Ee *et al.,* 2012
43	*G. nujiangensis*	Twig	Nujiangexanthones C-F, jacareubin, guttiferone F, cudratricusxanthone E, and garcihombronone B	Tang *et al.,* 2015
		Leaf	Nujiangexanthones A and B	Xia *et al.,* 2012
44	*G. oligantha*	Stem	Oliganthins A-D and gaudichaudione H	Gao *et al.,* 2012
		Leaf	Oliganthin H, I, K and L, oliganthic acids A-C, oliganthaxanthone A, oliganthaxanthone B, gaudichaudione H, and cantleyanone	Tang *et al.,* 2016
		Stem bark	Macluraxanthone	Waterman and Crichton 1980b
45	*G. opaca*	Leaf	Macluraxanthone, 1,3,5-trihydroxy-6’,6’-dimethylpyrano-(2,3’:6,7)-4-(l,l-dimethylprop-2-enyl)xanthone, 1,3,5-trihydroxy-6′,6′-dimethylpyrano(2′,3′:6,7)-2-(3-methylbut-2- enyl)-4-(1,1- dimethylprop-2-enyl)xanthone, and 4″,5″-dihydro-1,5-dihydro-1,5-dihydroxy-6′,6′-dimethylpyrano(2′,3′:6,7)-2-(3- methylbut-2-enyl)-4″,4″,5″-trimethylfurano(2″,3″:3,4) xanthone	Goh *et al.,*1992
46	*G. paucinervis*	Leaf	Paucinervins H-J	Li *et al*., 2016a
47	*G. parvifolia*	Twig	Parvifolixanthones A-C	Rukachaisirikul *et al.,* 2006
		Bark	Parvixanthones A−I	Xu *et al*., 2001
			Parvixanthone A and rubraxanthone	Kardono *et al.*, 2006
48	*G. pedunculata*	Bark	Pedunxanthones A–C, 1,5-dihydroxy-3- methoxy-6’,6’-dimethyl-2H-pyrano(2’,3’:6,7)-4-(3-methylbut-2-enyl)xanthone, 1,5-dihydroxy-3-meth-oxy-4-(3-methylbut-2-enyl)xanthone, dulxanthone A, and garbogiol	Vo *et al.,* 2012
		Heartwood	1,3,5,7-tetrahydroxyxanthone and 1,3,6,7-tetrahydroxyxanthone	Rao *et al.,*1974
		Pericarp	Pedunxanthones D-F	Vo *et al.,* 2015
49	*G. penangiana*	Leaf	4-(1,1-Dimethylprop-2-enyl)-1,3,5,8-tetrahydroxyxanthone penangianaxanthone, cudratricusxanthone H, macluraxanthone C, and gerontoxanthone C	Jabit *et al.,* 2007
50	*G. polyantha*	Stem bark	Bangangxanthone A and B, 1,5-dihydroxyxanthone, and 2-hydroxy-1,7-dimethoxyxanth- one	Lannang *et al.,* 2005
			Isorheediaxanthone B	Ampofo and Waterman, 1986
			Polyanxanthone	Komguem *et al*., 2006

		Root bark	Garciniaxanthone I, smeathxanthone A, smeathxanthone B, and chefouxanthone	Lannang *et al.,* 2008
		Wood trunk	Polyanxanthone A, B, C, 1,3,5-trihydroxyxanthone, 1,5-dihydroxyxanthone, 1,3,6,7-tetrahydroxy xanthone, 1,6-dihydroxy-5-methoxy xanthone, and 1,3,5,6-tetrahydroxy xanthone	Louh *et al.,* 2008
51	*G. porrecta*	---	Porxanthone A and dulxanthone E-G	Kardono *et al.,* 2006
52	*G. propinqua*	Twig	Doitunggarcinone C, dulxanthone B, 5-O-methylxanthone V1, 10-O-methylmacluraxanthone, macluraxanthone, gartanin, and morusignin J	Tantapakul *et al.,* 2012
		Root	Doitunggarcinone D	Meesakul *et al*., 2016
53	*G. pushpangadaniana*	Leaf	Cambogic acid and mangostin	Pandey *et al.,* 2015
54	*G. pyrifera*	Stem bark	Rubraxanthone, isocowanin, and isocowanol	Ampofo and Waterman, 1986
55	*G. quadrifaria*	Stem bark	1, 3, S-Trihydroxy-4, 8di(3, 3-dimethylallyl)xanthone	Waterman and Hussain, 1982
56	*G. rigida*	Leaf	Yahyaxanthone	Elya *et al.,*2008
			Musaxanthone and asmaxanthone	Elya *et al.,* 2006a
57	*G. schomburgkiana*	Bark	6-O-Demethyloliverixanthone, schomburgxanthone, cowanin, cowanol, fuscaxanthones A and B, 3-isomangostin hydrate, and 1,7-dihydroxyxanthone	Vo *et al.,* 2012a
		Root	Schomburgxanthone A	Sukandar *et al.,* 2016a
		Branch	Euxanthone and gentisein	Meechai *et al*., 2016
58	*G. scortechinii*	Twig	Scortechinones A-C	Rukachaisirikul *et al.,* 2000a
		Fruit	Scortechinones Q-T, scortechinones U-X, scortechinones A-F, H, I, M, L, and P	Sukpondma *et al.,* 2005
		Latex	Scortechinones D-K	Rukachaisirikul *et al.,* 2003b
59	*G. smeathmannii*	Stem bark	Smeathxanthone A and B	Komguem *et al.,* 2005
			Cheffouxanthone, 1,5 dihy- droxyxanthone, 1,3,5-trihydroxyxanthone, bangang xanthone A, smeathxanthone B, and smeathxanthone A	Kuete *et al.,* 2007
			1,3,5,8-Tetrahydroxy-2-(3-methybut-2-enyl)-4-(3,7-dimethylocta-2,6-dienyl)xanthone, cheffouxanthone, smeathxanthone A, smeathxanthone B, and ananixanthone	Fouotsa *et al.,* 2015
		Root bark	Cheffouxanthone , smeathxanthones A, and smeathxanthones B	Lannang *et al.,* 2006
60	*G. speciosa*	Bark	α-Mangostin, cowanin and cowanol	Okudaira *et al.,* 2000
61	*G. spicata*	Leaf	Cambogic acid and mangostin	Pandey *et al.,*

				2015
62	*G. staudtii*	Stem bark	Rheediaxanthone-A	Waterman and Hussain, 1982
		Twig	Staudtiixanthones A-D, α-mangostin, 9 garcinone B, 9 demethylcalabaxanthone, gartanin, and xanthone V_1	Ngoupayo *et al.,* 2009
63	*G. subelliptica*	Heartwood	Garciniaxanthones A and B	Fukuyama *et al.,* 1991
		Wood	Garciniaxanthone C, 1,2,5-trihydroxyxanthone, 2,6-dihydroxy-1,5-dimethoxyxanthone, and 1,2-dihydroxy-5,6-dimethoxyxanthone	Minami *et al.*, 1994
			2,5-Dihydroxy-1-methoxylxanthone, l-O-methylsymphoxanthone, garciniaxanthone E symphoxanthone, and subelliptenone A	Minami *et al.*, 1996
			1,6-O-Dimethylsymphoxanthone	Minami *et al.*, 1998
		Root bark	1,4,5,6-Tetrahydroxy-2-(1,1-dimethyl-2- propenyl)-7,8,-di-(3-methyl-2-butenyl)xanthone, and 1,2,5,6-tetrahydroxy-4-(1,l-dimethyl-2-propenyl)-7- (3-methyl-2-butenyl)xanthone, subelliptenones A and B	Iinuma *et al.*, 1994
			Subelliptenones C and subelliptenones D	Iinuma *et al.,*1995
			Subelliptenones H and subelliptenones I	Iinuma *et al.*, 1995a
			Subelliptenones E and subelliptenones F	Iinuma *et al.*, 1995b
64	*G. terpnophylla*	Timber and bark	1,5-Dihydroxyxanthone and mangostin	Bandaranayake *et al.,* 1975
65	*G. tetralata*	Stem bark	Garcinexanthone B, morellic acid acetate, toxyloxanthone A, 6,11-dihydroxy-2,2-dimethylpyrano[3,2-c]xanthen-7(2H)-one, and 1,4-dihydroxy-5,6-dimethoxy xanthone	Guo *et al.,* 2011
66	*G. tetrandra*	Stem bark	1,3-Dihydroxy,2′,2′-dimethyl pyrano (5′,6′,5,6) xanthone	Hartati *et al.*, 2008
67	*G. urophylla*	Leaf	7-Hydroxydesoxymorellin, isocaledonixanthone D, gaudichudione H, 1,7-dihydroxy-3-methoxy-2-(3-methyl- 2-butenyl)xanthone, 1,5-dihydroxy-3-methoxy-2-(3-methyl-2butenyl)xanthone, and 1,3,7-trihydroxy-2-(3-methyl-2-butenyl)xanthone	Khalid *et al.*, 2007
68	*G. vieillardii*	Stem bark	Vieillardiixanthones B and C, pancixanthones A, B, 1,6-dihydroxyxanthone, pyranojacareubin and 5,6-O-dimethyl-2-deprenylrheediaxanthone	Hay *et al.,* 2008
			1,6-Dihydroxyxanthone, pancixanthone A, isocudraniax- anthone B, isocudraniaxanthone A, 2-deprenyl rheediaxanthone B and 1,4,5-trihydroxyxanthone	Hay *et al.,* 2004
69	*G. vilersiana*	Bark	Globuxanthone, subelliptenone H, subelliptenone B, 12b-hydroxy-des-D-garcigerrin A, 1-*O*-methylglobuxanthone, and symphoxanthone	Nguyen *et al.*, 2000
70	*G. virgata*	Stem bark	Virgataxanthone A and B	Merza *et al.*, 2004
71	*G. yunnanensis*	Pericarp	Garciyunnanins A and B	Xu *et al.,* 2008

72	*G. wightii*	Leaf	Cambogic acid and mangostin	Pandey *et al.,* 2015
73	*G. xanthochymus*	Leaf	Cambogic acid and mangostin	Pandey *et al.,* 2015
		wood	1,4,5,6-Tetrahydroxy-7,8-di(3-methylbut-2-enyl)xanthone, 1,2,6-trihydroxy-5-methoxy-7-(3-methylbut-2-enyl)xanthone, and 12β- hydroxy- D-garcigerrin	Chanmahasathien *et al.,* 2003
		Bark	1,6-Dihydroxy-4,5-dimethoxyxanthone and 1,5,6-trihydroxy-7,8-di(3-methyl-2-butenyl)-60,60-dimethylpyrano(20,30:3,4) xanthone	Zhong *et al.,* 2007
			1,5,6- Trihydroxy-7-(3-methyl-2-butenyl)-8-(3-hydroxy-3-methylbutyl)furano(2′,3′:3,4) xanthone, 1,5,6-trihydroxy-7-(3-methyl-2-butenyl)- 8-(3-hydroxy-3-methylbutyl)–6′, 6′-dimethylpyrano (2′,3′:3,4) xanthone, 1,5,6-trihydroxy-7-(3- methyl-2-butenyl)-8-(3-hydroxy-3-methylbutyl)–5′-(1-hydroxy-1-methylethyl)-4′, 5′-dihydrofurano (2′,3′:3,4) xanthone, 1, 2, 5, 4′-tetrahydroxy-4-(1,1-dimethylallyl)-5′-(2-hydroxypropan-2-yl)-4′, 5′-dihydrofurano-(2′, 3′ : 6, 7)xanthone, 1, 3, 5, 6-tetrahydroxy-7-geranylxanthone, and 1, 4-dihydroxy-6′, 6′- dimethylpyrano (2′, 3′: 5, 6) xanthone	Chen *et al.,* 2010
			1,7-dihydroxyxanthone and 1,5-dihydroxyxanthone	Baslas and Kumar 1979
		Twig bark	1,4,6-Trihydroxy-5-methoxy-7-prenylxanthone, 1,4,5,6-tetrahydroxy-7-prenylxanthone, 1,2,5,6-tetrahydroxy-7-geranylxanthone, 1,4,5,6-tetrahydroxy-7,8-diprenylxanthone , 1,3,5,6-tetrahydroxy-4,7,8-triprenylxanthone , garciniaxanthone E, and 6-prenylapigenin	Han *et al*., 2007
74	*G. xipshuanbannaensis*	Twig	Bannaxanthone H, 1,3,5,6-tetrahydroxy-2-(3-methylbut-2-enyl)xanthone, bannaxanthone F, garcinone C, 1,3,6,7-tetrahydroxy-8-(3-methylbut-2-enyl)xanthone, bannaxanthone G, bannaxanthone B, γ-mangostin, garcinone E, bananxanthone E, allanxanthone C, bannaxanthone D, 1,3,5,6-tetrahydroxy-7-(3-methylbut-2-enyl)xanthone, xanthone V1a, and nigrolinexanthone V	Zhou *et al.,* 2008
			Bannaxanthones A-H, allanxanthone C, isojacareubin, garcinone C, and γ-mangostin	Han *et al.,* 2008

2. Benzophenones

Benzophenones are a series of compounds with phenol-carbonyl-phenol skeleton, synthesised through the mixed shikimic acid and acetate pathway, in which the acetate derived benzene ring is modified by intervention of prenyl groups. Biogenetically isoprenylated benzophenones are derived from maclurin which was regarded as a precursor for many xanthones in higher plants. Garciduols A-E, reported from *G. dulcis* possesses the novel benzophenone xanthone dimer skeletal structure, supporting the biosynthetic route that benzophenones are precursors of xanthones (Iinuma *et al.,*1996). Naturally occurring benzophenones that consists of more than 300 members are reported with great structural diversity with oxidized and polyisoprenylated structures (Cuesta-Rubio *et al.,* 2005, Acuna *et al.,* 2009). The genus *Garcinia* and *Clusia* are the major source of natural benzophenones. Literature review revealed that out of 120 *Garcinia* species subjected to phytochemical investigation, 50 *Garcinia* species contain benzophenones (**Table 2**). Floral resins and latex of some of the Clusiaceae members are mainly constituted of benzophenones and can contain up to 70% of benzophenones (Cuesta-Rubio *et al.,* 2001).

Generally the benzophenones can be classified into simple polyisoprenylated benzophenones and complex bicyclo-[3.3.1]-nonane derivatives (**Figure 3, Figure 4**). Most of the benzophenones reported from the genus *Garcinia* are polyisoprenylated bezophenones, derived from maclurin. Karanjgoakar *et al.* in 1973 isolated xanthochymol, the first bicyclo-[3.3.1]-nonane benzophenone from the fruits of *G. xanthochymus* (Karanjgoakar *et al.,* 1973). Camboginol (garcinol) and cambogin (isogarcinol; xanthochymol) were two important benzophenones isolated from the latex of *G. gummi-gutta* in large quantities (37.0% and 5.5% respectively) (Rao *et al.,* 1980). Porto *et al* (2000) attempted a chemotaxonomical approach based on the distribution of benzophenones in the floral resins of *Clusia* members, where simple benzophenone derivatives and the bicyclo-[3.3.1]-nonane benzophenone structures demarcated the species.

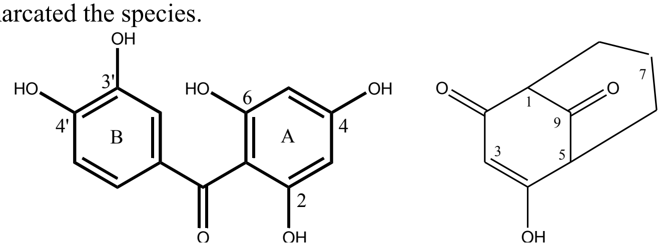
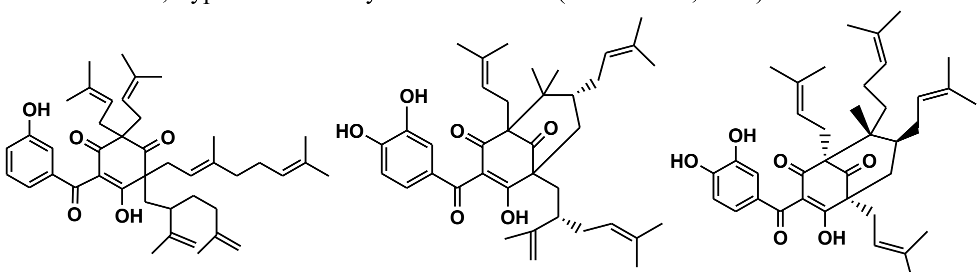


Figure 3. Typical benzophenone (maclurin) and bicyclo-[3.3.1]-nonane 2,4,9-trione structure

Recent developments in phytochemical analytical methods, especially the hyphenated LC-MS techniques, made tremendous contributions to the detection of secondary metabolites that are present in minute quantities in plants. The limit of detection for xanthochymol in *G. indica* fruit rinds was reported as 20 µg/mL by HPLC and the method was inadequate to detect or estimate xanthochymol present in minute quantity in other parts of the plant. Consequently, LC-ESI/MS/MS method has been developed for the detection and quantification of xanthochymol at ppb level in *Garcinia* species. In addition, the isomeric compound isoxanthochymol can be differentiated from xanthochymol by the fragment ions obtained through MS/MS (Chattopadhyay and Kumar, 2006). Powder X-ray diffraction (PXRD) technique has been reported as a non-destructive analytical tool for the detection of the anti-HIV benzophenones, 7-*epi*-clusianone and guttiferone in *G. brasiliensis* extracts by Martins, *et al*., (2011). The compounds were detected in plant powder by comparing the powder diffraction profile of raw plant powder with the reported single crystal profiles of marker compounds (Martins, *et al*., 2011).

Benzophenones have shown different biological properties especially activity against HIV-1 (Cuesta-Rubio *et al.,* 2005). Garcinol is an important polyisoprenylated benzophenone distributed in several *Garcinia* species and is one of the active ingredients of nutraceutical products from *G. indica* and *G. cambogia*. The structural similarity with curcumin, with *β*-diketone moiety that shows keto enol tautomerism, make garcinol interesting for pharmacological screening studies (Padhye *et al*., 2009). The significant antioxidant activity of Kokum syrup, a delicious drink popular in northern Kerala and Konkan region, made from *G. indica* fruits, is attributed mainly to the presence of garcinol and anthocyanins (Mishra, *et al*., 2006). Guttiferones, another class of benzophenones isolated from *Garcinia* species such as *G. pyrifera* and *G. aristata* are of great interest in pharmaceutical research particularly due to the anti-HIV, trypanocidal and cytotoxic activities (Acuna *et al*., 2009).



Semsinone B **Garcinol** **Guttiferone A**

Figure 4. The simple benzophenone (semsinone B) and the bicyclo-[3.3.1]-nonane benzophenones (garcinol and guttiferone A)

Table 2. Benzophenones reported from *Garcinia* species

Sl. No.	*Garcinia* species	Plant part	Benzophenones	Reference
1	*G. achachairu*	Seed	Guttiferone A	Dal Molin *et al.,* 2012
2	*G. amplexicaulis*	Stem bark	Garcinal	Lavaud *et al.,* 2015
3	*G. aristata*	Fruit	Aristophenones A-B	Cuesta-Rubio *et al*., 2001
		Fruit	Guttiferone A, xanthochymol, and Guttiferone E	Acuna *et al.,* 2012,
4	*G. assigu*	Stem bark	Isogarcinol, garcinol ,18-0-methyl isogarcinol 18-0-methyl garcinol, and clusianone	Ito *et al.,* 2003
5	*G. benthami*	Stem bark	Benthaphenone	Nguyen *et al.,* 2011a
			Salimbenzophenone	Elya *et al*., 2006
6	*G. brasiliensis*	Fruit	7-epi-Clusianone and guttiferone A	Martins *et al.,* 2011
		Pericarp	7-epi-Clusianone, garciniaphenone, and guttiferone-A	Pereira *et al.,* 2010
		Leaf	7-epi-Clusianone	Santa-Cecília *et al.,* 2011
		Epicarp	7-epi-Clusianone and garciniaphenone	Derogis *et al.,* 2008
			7-epi-Clusianone	Castro *et al.,* 2015
7	*G. cantleyana*	Twig	2,6,3’,5’-Tetrahydroxybenzophenone,	Jantan *et al.,*

			3,4,5,3’,5’-pentahydroxybenzophenone, and 3,5,3’,5’-tetrahydroxy-4-methoxybenzophenone	2012
8	*G. cochinchinensis*	Pericarp	Guttiferones Q-S and guttiferone I	Nguyen *et al.,* 2011
9	*G. cowa*	Leaf	Chamuangone	Sakunpak and Panichayupakara nt, 2012
			Garcinol	Pandey *et al.,* 2015
10	*G. echinocarpa*	Leaf	Garcinol	Pandey *et al.,* 2015
11	*G. epunctata*	Stem bark	Epunctanone, 7-epiisogarcinol	Fotso *et al.,* 2014
12	*G. eugenifolia*	Root	(3,4-Dihydroxyphenyl),(3-hydroxy-5-methoxyphenyl) methanone, and (3- hydroxy-phenyl)3,4,5-trihydroxy phenyl) methanone	Joong *et al.,* 2012
		Stem bark	Eugeniaphenone	Hartati *et al.*, 2008a
13	*G. griffithii*	Stem bark	Guttiferone I	Nguyen *et al.,* 2005
			Isoxanthochymol and guttiferone I	Elfita *et al.,* 2009
14	*G. gummi-gutta* (*G. cambogia*)	Fruit	Garcinol, guttiferones K, I, J, M and N Garcinol, guttiferones- K, I, J, M and N Guttiferone I, guttiferone N, guttiferone J, guttiferone K, and guttiferone M	Masullo *et al.,* 2008 Masullo *et al.,* 2010 Semwal *et al.,* 2015
		Latex	Cambogin (isogarcinol) and camboginol (garcinol)	Rao *et al.,*1980
		Leaf	Garcinol	Pandey *et al.,* 2015
		Bark	Guttiferone E and isogarcinol	Semwal *et al.,* 2015
15	*G. hombroniana*	Leaf	Garcinol	Pandey *et al.,* 2015
		Stem wood	Bronianone	Rao *et al.,* 1973 Ollis *et al.*, 1969
		Fruits	Guttiferone A, xanthochymol, and guttiferone E	Acuna *et al.,* 2012
		Bark	2,3',4,5'-Tetrahydroxy-6-methoxybenzophenone, 2,3',4,4'-tetrahydroxy-6-methoxybenzophenone, and 2,3',4,6-tetrahydroxybenzophenone	Jamila *et al.,* 2014b
16	*G. huillensis*	Stem bark	Garcinol	Phongi *et al.,* 1987
17	*G. indica*	Leaf	Garcinol	Pandey *et al.,* 2015
		All parts	Xanthochymol and isoxanthochymol	Chattopadhyay *et al.,* 2006 Kumar *et al.*, 2009.
		Fruit	Isogarcinol, garcinol, and 14-deoxyisogarcinol	Kaur *et al.,* 2012
18	*G. intermedia*	Fruit	Guttiferone A, xanthochymol, and	Acuna *et al.,*

			guttiferone E	2012
19	*G. kola*	Fruit	Guttiferone A, xanthochymol, kolanone, and guttiferone E	Acuna *et al.,* 2012 Waterman *et al.,* 1983
			Kolanone	Hussain *et al*., 1982
20	*G. livingstonei*	Fruit	Guttiferone A, xanthochymol, and guttiferone E	Acuna *et al.,* 2012
			Guttiferone A	Gustafson *et al*., 1992
21	*G. macrophylla*	Twigs	Guttiferone A and guttiferone G	Williams *et al.,* 2003
22	*G. maingayii*	Stem bark	Isoxanthochymol and camboginol	Hartati *et al*., 2007
23	*G. mangostana*	Leaf	Garcinol	Pandey *et al.,* 2015
		Heart wood	3’,6-Dihydroxy-2,4,4’- trimethoxy benzophenone	Nguyen *et al.,* 2005
		Fruit	Guttiferone A, xanthochymol, and guttiferone E	Acuna *et al.,* 2012
		Fruit hull	2,4,6,7- Tetrahydroxyxanthone, 3,4,5,3’-tetrahydroxybenzophenone, and 2,4,6,3’,5’-pentahydroxybenzophenone	Jiang *et al.,* 2010
			Garcimangosone D	Huang *et al.,* 2001
		Stem bark	Mangaphenone	See *et al.,* 2014
24	*G. mannii*	Stem bark	Xanthochymol	Crichton *et al.,* 1979
25	*G. morella*	Leaf	Garcinol	Pandey *et al.,* 2015
26	*G. multiflora*	Bark, stem	4,6,4'-Trihydroxy-2,3'-dimethoxy-3-prenylbenzophenone	Chiang *et al.,* 2003
		Fruit	13,14-Didehydoxyisogarcinol, garcimultiflorone A, garcimultiflorone B, 13-hydroxy garcimultiflorone B, and garcimultiflorone C	Chen *et al.,* 2009.
27	*G. myrtifolia*	Bark	Myrtiaphenone-A, B and vismiaphenone C	Spino *et al.,* 1995
28	*G. ovalifolia*	Leaf	Guttiferone E	Gustafson *et al.,* 1992
		Stem bark	Xanthochymol and isoxanthochymol	Waterman and Crichton, 1980b
		Fruit	Xanthochymol	Waterman *et al.,* 1980b
		Root	Epigarcinol and isogarcinol	Pieme *et al.,* 2015
29	*G. paucinervis*	Leaf	Paucinones A-D	Gao *et al.,* 2010
		Seed	Paucinones E–I	Li *et al*., 2016
30	*G. pedunculata*	Fruit	Pedunculol, garcinol, and cambogin	Sahu *et al.,*1989
		Heart	2,4,6,3’,5’-Pentahydroxybenzophenone	Rao *et al.,* 1974

		wood		
31	*G. picrorrhiza*	Bark	Garcinopicobenzophenone and guttiferone F	Soemiati *et al.*, 2006
32	*G. polyantha*	Stem bark	Xanthochymol and isoxanthochymol	Ampofo and Waterman, 1986
33	*G. propinqua*	Twig	Doitunggarcinones A and B	Tantapakul *et al.,* 2012
34	*G. pseudoguttifera*	Heart wood	Myrtiaphenone-A, myrtiaphenone-B, myrtiaphenone-C, and pseudoguttiaphenone-A	Ali *et al.,* 2000
35	*G. purpurea*	Pericarp	Xanthochymol, cambogin (isogarcinol), and camboginol (garcinol)	Matsumoto *et al.,* 2003 Iinuma *et al.,* 1996 Steller, 1995
36	*G. pushpangadaniana*	Leaf	Garcinol	Pandey *et al.,* 2015
37	*G. pyrifera*	Fruit	Guttiferone E and Xanthochymol	Roux *et al.,* 2000
38	*G. schomburgkiana*	Fruit	Schomburgkianones A-H	Le *et al*., 2016
39	*G. semseii*	Stem bark	Semsinones A-C	Magadula *et al.,* 2008
40	*G. smeathmannii*	Stem bark	Guttiferone I and isoxanthochymol	Kuete *et al.,* 2007
		Root bark	Guttiferone I and isoxanthochymol	Lannang *et al.,* 2006
41	*G. solomonensis*	Stem bark	Guttiferones O and P	Carrol *et al.,* 2009
42	*G. speciosa*	Trunk bark, stem	Garciosaphenone	Rukachaisirikul *et al.,* 2003a
43	*G. spicata*	Leaf	Garcinol	Pandey *et al.,* 2015
		Fruit	Guttiferone A, xanthochymol, and guttiferone E	Acuna *et al.,* 2012
44	*G. staudtii*	Stem bark	Xanthochymol	Waterman and Hussain, 1982
45	*G. subelliptica*	Fruits	Garcinialiptone A, garcinialiptone B, (−)-cycloxanthochymol, garcinialiptone C, garcinialiptone D, xanthochymol, isoxanthochymol, and cycloxanthochymol	Zhang *et al.,* 2010
		Wood	4′,6-dihydroxy-2,3′4-trimethoxybenzophenone	Minami *et al.,* 1994
46	*G. vieillardii*	Stem bark	Clusiachromene and 3-geranyl-2,4,6-trihydroxybenzophenone	Hay *et al.,* 2008
47	*G. virgata*	Stem bark	Guttiferone E, xanthochymol, and guttiferones I and J	Merza *et al*., 2006
48	*G. wightii*	Leaf	Garcinol	Pandey *et al.,* 2015
49	*G. xanthochymus*	Leaf	Garcinol	Pandey *et al.,* 2015
		Fruit	Guttiferone H and gambogenone	Bagget *et al.,* 2005

			Guttiferone A, xanthochymol, and guttiferone E	Acuna *et al.,* 2012
			Xanthochymol and garcinol	Jackson *et al.,* 2015
			Xanthochymol, Isoxanthochymol, and maclurin	Baslas and Kumar 1979
50	*G. xipshuanbannaensis*	Twig	Guttiferone E and xanthochymol	Han *et al*., 2008

3. Biflavonoids

Biflavonoids are a distinct class of naturally occurring flavonoid dimers linked by a C-C or C-O-C bond. The biogenesis of biflavonoids involves the radical pairing of two embryonic flavonoid units. The ring B and C of flavonoid units were formed through shikimic acid pathway, while ring A is formed through acetate pathway (**Figure 5**). Depending on the monomeric unit like flavones, flavanones, isoflavones, flavanols, chalcones, aurones and dihydrochalcones, different combinations of flavonoid dimers such as flavanone-flavone, flavones-flavone, flavone-flavonol are possible. Naturally occurring biflavonoids contains hydroxy or methoxy groups substituted at different positions leading to diverse array of biflavonoids (Mercader and Pomilio, 2012). Amentoflavones with the 3-8 linkage is considered as the primitive or basic form of biflavonoids in vascular plants.

The rapid growth in literature on biflavanoids led to various systems of naming and though systematic IUPAC and Locksley names exists, most of the biflavonoids are known by their vernacular names (Locksley, 1973). In Locksley system, for example, amentoflavone is named as I-4', II-4', I-5, II-5, I-7, II-7-hexahydroxy I-3', II-8 biflavone, while in IUPAC system, amentoflavone is named as 8-5-(5,7-dihydroxy-4-oxo-4H-chromen-2-il)-2-hydroxyphenyl-5,7-dihydroxy- 2-(4-hydroxy-phenyl)-chromen-4-on. Basic difference between the two systems is reference of structural skeleton, where Locksley use flavanoid structure, while IUPAC use chromen structure (Rahman *et al.,*2007).

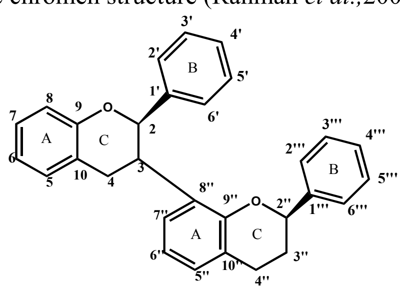


Figure 5. Numbering in typical biflavonoid structure

The distribution of biflavonoids is limited to some plant groups, especially in the primitive orders such as Bryales, Psilotales and Selaginellales, and sporadically in the angiosperms. According to Gieger and Quinn (1988), angiosperms lost the capacity to biosynthesis biflavonoids in the course of evolution, but was regained by a selected family. The genus *Garcinia* is a rich source of biflavonoids and out of the 120 *Garcinia* species studied for their secondary metabolites, biflavonoids were reported from 45 species (**Table 3**).

Majority of the naturally occurring biflavonoids contain C-C linked monomers and I(3)-II (8) linkage is the most prevalent inter-linkage in *Garcinia* biflavonoids (Yamaguchi *et al*., 2008). Biflavonoids reported from the *Garcinia* species with 3-8'' interflavonoid linkage can generally be divided into two subgroups; biflavonones made up of two flavanone units (GB type of biflavonoids) and those made up of one flavanone and one flavone subunits (morelloflavone and volkensiflavone) (**Figure 6**). Of the two types, biflavonones is the major type in *Garcinia* species whereas the co-occurrence of the two types of biflavonoids is rare (Waterman and Hussain, 1983). Morelloflavone, isolated from *G. morella* in 1967 is the first biflavonoid reported with a flavone and a flavonone unit (Karanjgaokar *et al*., 1967). Amentoflavone (5′,8″-biapigenin) is the common example for I(5′)-II(8) biflavonoid distributed in *Garcinia* species. It is interesting to note that the biflavonoid linkage has potential significance in systematic (Waterman and Husain, 1983).

Biflavonoids generally exist as rotamers and can be monitored by variable temperature NMR studies, where at room temperature the biflavonoids exhibit duplicate NMR signals, while at elevated temperature a single set of signals was obtained (Jamila, *et al*., 2014). Mass spectrometry is perhaps the most informative tool for structure elucidation of biflavonoids (Zhang *et al*., 2011). The most useful fragmentations in terms of structural identification are those involving the C-ring cleavage of biflavonoids. Fragmentation peaks for phloroglucinol (m/z 126), p-methoxy benzyl (m/z 138), p-hydroxy benzyl (m/z 124) and retro Diels Alder cleavage products are usually observed for biflavonoids.

A variety of biological activities like anti inflammatory, anti HIV, antifungal, anti tumor, hypocholesterolemic, and anti-plasmodial were attributed to biflavonoids (Gil *et al*., 1997, Lin *et al*., 1997 Yamaguchi *et al*., 2008, Pang *et al*., 2009). Of the different activities, antioxidant activity is of highly significant, where biflavonoids inhibits transition metal ions in free radical generating reactions by complexing and quenching the metal ions (Yamaguchi, *et al*., 2008).

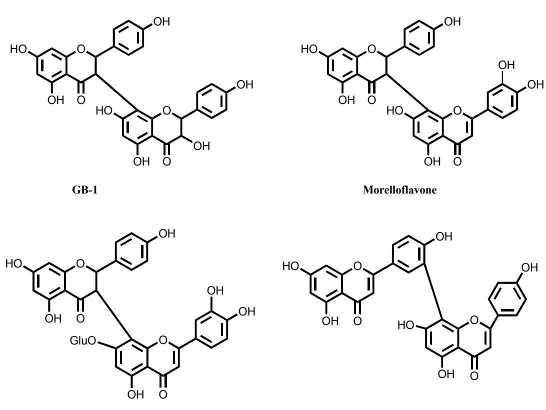


Figure 6. Structures of I(3)-II(8) linked biflavonones (GB1), flavanone-flavone (morelloflavone), flavanone-flavone glycoside (fukugiside) and I(5')-II(8) linked biflavone (amentoflavone)

Table 3. Biflavonoids reported from *Garcinia* species

Sl. No.	*Garcinia* species	Plant part	Biflavonoids	Reference
1	*G. atroviridis*	Stem bark	Garcineflavonol	Tan *et al.,* 2014
2	*G. bakeriana*	Leaf	4'''-O-Methyl-I3,II8-biapigenin, amentoflavone, 4'''-O-methylamentoflavone , 4'-O-methylcupressuflavone, GB-2a, volkensiflavone, 6"-(2-hydroxy-3-methyl-3-butenyl)-amentoflavone, I3,II8-biapigenin, and GB-1a	Al-Shagdari *et al.,* 2013
3	*G. brasiliensis*	Epicarp	Morelloflavone, morelloflavone-4‴-O-β-D-glycoside, and morelloflavone-7″-O-β-D-glycoside	Gontijo *et al.,* 2012
			Fukugetin	Castro *et al.,* 2015
		Branch, leaf	Procyanidin, fukugetin, amentoflavone, and podocarpusflavone	Arwa *et al*, 2015
4	*G. brevipedicellata*	Heart wood	Amentoflavone , 4‴′-O-methyl amentoflavone, Robustaflavone, 4′-O-methyl robustaflavone, and tetrahinokiflavone	Abderamane *et al*., 2016
5	*G. buchananii*	Stem bark	GB-1, GB1a, GB-2 and GB-2a	Jackson *et al.,* 1968 and 1971
			(2R,3S,2″R,3″R)-Manniflavanone, (2R,3S,2″R,3″R)- isomanniflavanone, (2″R,3″R)-preussianone, (2R,3S,2″R,3″R)-GB-2 7″-O-β-D-glucopyranoside, and (2R,3S,2″R,3″R)-manniflavanone-7″-O-β-D-glucopyranoside	Stark *et al*., 2015
			(2R,3S,2″R,3″R)-Manniflavanone, (2R,3S,2″R,3″R)-GB-2 and (2R,3S,2″S)-buchananiflavanone	Stark *et al*., 2012
6	*G. conrauana*	Stem bark Heart wood	GB-1, GB1a, GB-2, morelloflavone, O-methyl fukugetin, and O-methyl fukugetin glycoside	Hussain and Waterman, 1982
7	*G. cornea*	Stem bark	Morelloflavone and fukugiside	Elfita *et al*., 2009
8	*G. cowa*	Branch	GB-2, morelloflavone, volkensiflavone, and fukugiside	Shen and Yang, 2007; Panthong *et al.,* 2009
		Fruit	Amentoflavone and morelloflavone	Shen and Yang, 2006
		Leaf	Fukugicide, amentoflavone, GB-1, and GB-2	Pandey *et al.,*2015
9	*G. cymosa*	Stem bark	Morelloflavone and morelloflavone-7”-*O*-β-D-glucoside	Elfita *et al.,* 2009
10	*G. densivenia*	Stem bark	Morelloflavone and O-methyl fukugetin	Waterman and Crichton, 1980a
11	*G. dulcis*	Leaf	Amentoflavone, fukugetin, volkensiflavone, and flavanone-(1-3:11-8)-chromone, 1-4’ (flavanone- chromone)	Ansari *et al.,* 1976

			Dulcisbiflavonoid A	Saelee *et al.,* 2015
			Morelloflavone	Pinkaew *et al.,* 2009
		Branch	Podocarpusflavone A	Harrison *et al.,* 1994
		Fruit	Dulcisbiflavonoid A	Saelee *et al.,* 2015
12	*G. echinocarpa*	Timber, bark	Volkensiflavone, morelloflavone, and fukugetin	Bandaranayake *et al.,*1975
		Leaf	Fukugicide, GB-1 and amentoflavone	Pandey *et al.,* 2015
13	*G. eugeniifolia*	Heart wood	GB-1, GB-1a, GB-2 and GB-2a	Jackson *et al*., 1968 and 1969
14	*G. fusca*	Root	Vokensiflavone, fukugetin, fukugiside	Nontakham *et al.,* 2014
15	*G. gardneriana*	Leaf	Fukugetin and GB-2a	Castardo *et al.,* 2008
16	*G. gummi-gutta* (*G. cambogia*)	Leaf	Fukugicide, GB-1, and amentoflavone	Pandey *et al.,* 2015
		Heart wood, bark	Morelloflavone, dihydromorelloflavone and isomorellic acid	Venkataraman, 1973
17	*G. hombroniana*	Bark	Volkensiflavone, volkensiflavone-7-O-rhamnopyranoside, 4″-O-methyl-volkensiflavone, volkensiflavone-7-O-glucopyranoside, morelloflavone, 3″-O-methyl-morelloflavone, and morelloflavone-7-O-glucopyranoside	Jamila *et al.,* 2014
		Leaf	Fukugicide, GB-1, GB- 2, GB-1a, and amentoflavone	Pandey *et al.,* 2015
18	*G. indica*	Heartwood	Fukugetin and volkensiflavone	Cotterill *et al*., 1977
		Leaf	Fukugicide, GB-1, GB- 2, and amentoflavone	Pandey *et al.,* 2015
19	*G. intermedia*	Leaf	Podocarpusflavone A and amentoflavone	Abe *et al.,* 2004
20	*G. kola*	Stem bark	I-3’, II-3, 3’, II-4’, I-5, II-5, I-7, II-7-Octahydroxy-1- 4’-methoxy-1-3, II-8-biflavanone, GB-1, and GB-2	Kabangu *et al.,* 1987
		Root	GB1, GB-2, kolaflavanone, manniflavanone, and garciniflavanone	Iwu *et al.,*1990
			GB 1	Han *et al*., 2005
		Seed	Amentoflavone, kolaflavone, GB-1, and GB-2	Iwu *et al.,*1982
			GB-1 and GB-2	Terashima *et al.,* 1997
			Kolaflavanone, GB-1, GB-1a, and GB-2	Kapadia *et al.,* 1994
			GB-1 and GB-2	Madubunyi, 1995

			Garcinianin	Terashima *et al*., 1995
			Kolaflavanone, GB-1, GB-1a, and GB-2	Tshibangu *et al*., 2016.
		Stem	Garcinianin, biflavanone GB-2a, (+) GB-1, (-) GB-1a, biapigenin,3-8'', and amentoflavone	Terashima *et al.,*1999, 1999a
21	*G. lateriflora*	Stem bark	Morelloflavone	Ren *et al.,* 2010
22	*G. linii*	Bark	Fukugetin, GB-1, GB- 2, GB-1a, and GB 2a	Konoshima *et al*., 1970
23	*G. livingstonii*	Heartwood, bark, leaf	Morelloflavone, BGH-III, amentoflavone podocarpusflavone A	Pelter *et al.,* 1971
		Fruit	Amentoflavone, 3,8″-biapigenin, volkensiflavone, morelloflavone and fukugiside	Yang *et al.,* 2010
		Root bark	Ent-naringeninyl-(I-3α, II-8)-4'-*O*-methylnaringenin	Mbwambo *et al.,* 2006
		Leaf	Amentoflavone and 4"-methoxy amentoflavone	Kaikabo *et al*., 2009
24	*G. madruno*	Leaf	Morelloflavone, volkensiflavone and amentoflavone	Osorio *et al.,* 2009
			7"-O-(6""-Acetyl) glucoside of morelloflavone, fukugiside, and spicataside	Osorio *et al.,* 2013
25	*G. mangostana*	Leaf	Fukugicide, GB-1, GB- 2, GB-1a, and amentoflavone	Pandey *et al.,* 2015
26	*G. mannii*	Stem bark	Manniflavanone, morelloflavone, and O-methyl fukugetin	Hussain *et al.,* 1982
			GB-1, GB-2, and manniflavanone	Crichton *et al.,* 1979
		Leaf	GB-1, GB-2, and manniflavanone	Hussain *et al.,* 1982
		Seed	GB-1, GB-2, and manniflavanone	Hussain *et al.,*1982
27	*G. merguensis*	Twig	GB-1a, GB-2a, (+)-morelloflavone, (+)-volkensiflavone, and amentoflavone	Trisuwan *et al.,* 2013
28	*G. morella*	Bark	Dihydromorelloflavone, morelloflavone-7''-β-glucoside, fukugetin, and fukugiside	Adawadkar *et al.,*1976
		Leaf	Fukugicide, GB-1, GB- 2 ,GB-1a, and amentoflavone	Pandey *et al.,* 2015
29	*G. multiflora*	Heartwood	(-)-GB-1a, (+)- GB-2a, (+) volkensiflavone, (+) morelloflavone, spicataside, fukugiside, xanthochymuside, 3, 8''-binaringenin-7''-O-β-glucoside, GB-1a, GB-2a, volkensiflavone, and morelloflavone	Chen *et al.,* 1975
			Fukugetin, fukugiside, GB-1a, GB-2a and GB-1a 7''-O-β-D-glucoside, and I-5, II-5, I-7, II-7, I-3', I-4', II-4'- heptahydroxy- [I-3,II-8]-flavanonyl- flavones	Lin *et al.,*1997

		Bark	Fukugetin, GB-1, GB- 2 ,GB-1a, GB-2a, and volkensiflavone	Konoshima *et al*., 1970
30	*G. nervosa*	Leaf	I-5, II-5, I-7, II-7, I-3’, I-4’, II-4’- Heptahydroxy- [I-3, II-8]- flavanonyl flavones and I-3, II-3, I-5, II-5, I-7, II-7, I-4', II-4'- octahydroxy [I-2', II-2'] biflavone	Babu *et al.,* 1988 Parveen *et al.,* 2004
31	*G. pedunculata*	Heart wood	GB-1a and volkensiflavone	Rao *et al.,* 1974
32	*G. prainiana*	Stem bark	Morelloflavone, O-methyl fukugetin, volkensiflavone, amentoflavone, and 4′′′-methoxyamentoflavone	On *et al*., 2016
33	*G. preussii*	Leaf	Preussianone	Messi *et al.,* 2012
34	*G. pushpangadaniana*	Leaf	Fukugicide, GB-1, GB- 2 ,GB-1a, and amentoflavone	Pandey *et al.,* 2015
35	*G. quadrifaria*	Stembark Seed	Fukugetin and O-methyl fukugetin	Waterman and Hussain, 1982
36	*G. schomburgkiana*	Fruit	GB-1a, GB-2a, morelloflavone, and volkensiflavone	Le *et al*., 2016
37	*G. scortechinii*	Fruit	(+) Volkensiflavone and (+) morelloflavone	Sukpodma *et al.,* 2005
38	*G. spicata*	Leaf	GB-1, GB-1a, GB-2a, and fukugetin	Gunatilaka *et al.,* 1984
			Fukugicide, GB-1, GB- 2 ,GB-1a, and amentoflavone	Pandey *et al.,* 2015
		Bark	Fukugetin and 3-O-methyl fukugetin	Konoshima and Ikeshiro, 1969
			Fukugiside	Konoshima and Ikeshiro, 1970
			Volkensiflavone, spicataside, biflavonoid glycoside, GB-la, and GB-2a	Konoshima *et al.,* 1970a
39	*G. subelliptica*	Pericarp	Podocarpusflavone A	Iinuma *et al.,* 1996
		NSf	2R,3S-5,7,4',5",7",3"',4"'-Heptahydroxy flavanone[3-8"] flavone, and 5,7,4',5",7",3"',4"'-heptahydroxy[3-8"] biflavanone	Masuda *et al.,* 2005
40	*G. talboti*	Root	Talbotaflavone and morelloflavone	Joshi *et al*., 1970
41	*G. terpnophylla*	Timber, bark	GB-1a, GB1 and GB-2, 3’’-3’’’-4’-4’’’-5-5’’-7-7’’-Octahydroxy-(3-8’’) biflavanone, 3’’-4’-4’’’-5-5’’-7-7’’-heptahydroxy-(3-8’’) biflavanone, and 4’-4’’’-5-5’’-7-7’’-hexahydroxy -(3-8’’) biflavanone	Bandaranayake *et al.,*1975
		Wood	3’’-3’’’-4’-4’’’-5-5’’-7-7’’-Octahydroxy-(3-8’’) biflavanone and 3’’-4’-4’’’-5-5’’-7-7’’-heptahydroxy-(3-8’’) biflavanone	Bandaranayake *et al.,*1975
42	*G. thwaitesii*	Timber, bark	II-3, I-4’, II-4’, I-5, II-5,I-7,II-7- Heptahydroxy (I-3,II-8) biflavanone, I-4’, Ii-4’, I-5, II-5,I-7,II-7-hexahydroxy (I-3,II-8) biflavanone, II-3,II-3’,I-4,II-4’,I-5,II-5,I-7,II-7- octahydroxy (I-3,II-	Gunatilaka *et al.,* 1983

			8) biflavanone, I-4', II-3', II-4', I-5, II-5, I-7, II-7-heptahydroxy (I-3,II-8) biflavanone, I-4'-II-3'-II-4'-I-5-II -5-I-7-II-7-Heptahydroxy-(I-3-II-8) biflavanone, I-4'-II-4'-I-5-II-5-I-7 –II-7-hexahydroxy-(I-3-II-8) biflavanone, II-3-I-4'-II-4'-I-5-II-5-I-7-heptahydroxy-(I-3-II-8) biflavanone, II-3-II-3'-I-4'-II-4'-I -5-II-5-I-7-II-7-octahydroxy-(I-3-II-8) biflavanone, I-4'-II-3'-II-4'-I-5-II -5-I-7-II-7-Heptahydroxy-(I-3-II-8) biflavanone, I-4'-II-4'-I-5-II-5-I-7 –II-7-hexahydroxy-(I-3-II-8) biflavanone, and II-3-I-4'-II-4'-I-5-II- 5-I-7-II-7-heptahydroxy-(I-3-II-8) biflavanone	
43	*G. volkensii*	Heartwood	GB-1a, GB-2a, morelloflavone, and volkensiflavone	Herbin *et al.,* 1970
44	*G. wightii*	Leaf	Fukugicide, GB-1, GB- 2, GB-1a, and amentoflavone	Pandey *et al.,* 2015
45	*G. xanthochymus*	Leaf	Agathisflavone and 7-O-methyl amentoflavone	Parveen *et al.,* 1994
			Fukugicide, GB-1, GB- 2, GB-1a, and amentoflavone	Pandey *et al.,* 2015
		Fruit	Volkensiflavone, morelloflavone, GB-1, and GB-1a	Baslas and Kumar 1979
			3-8''- 3''-4'-4'''-5-5''-7''-Heptahydroxy biflavanone, 3-8''- 4'-4''-5-5''-7-7''-hexahydroxy biflavanone, fukugetin, and volkensiflavone	Baslas and Kumar 1981
		Leaf, root and fruit	GB-2a glucoside, GB-2a, and fukugetin	Li *et al.,*2014
		Wood, leaf	GB-1a, GB-2, volkensiflavone, fukugiside, xanthochymoside, and morelloflavone	Konoshima *et al.,* 1970

4. Depsidones

Depsidones comprise benzoic acid and phenol skeletons condensed at the *ortho*-positions through ester and ether linkages (**Figure 7**). This class of compounds is well known in *Garcinia* species (Ha *et al.,* 2012).

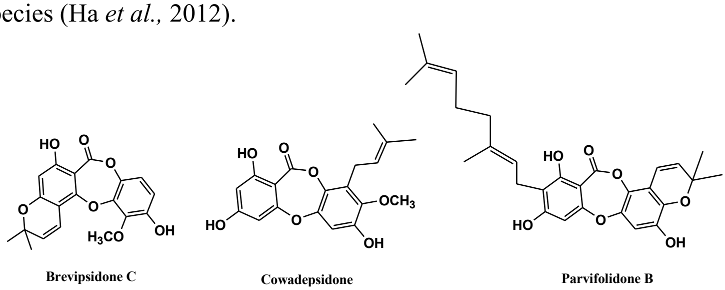


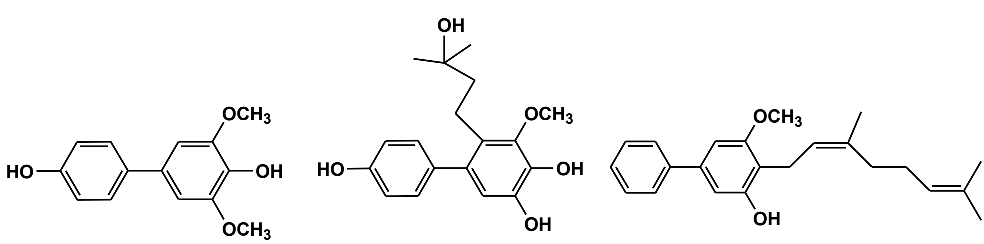
Figure 7. Structures of brevipsidone C (simple despidone), cowadespidone (monoprenylated despidone) and parvifolidone B (geranyl substituted despidone)

Table 4. Despidones reported from *Garcinia* species

Sl. No.	*Garcinia* species	Plant part	Depsidones	Reference
1	*G. assigu*	Stem bark	Garcinisidone A	Ito *et al*., 1997
2	*G. atroviridis*	Root	Atrovirisidone, Atrovirisidone B	Permana *et al*., 2001, 2005
3	*G. brevipedicellata*	Stem bark	Brevipsidones A-D	Ngoupayo *et al*., 2008
4	*G. buchananii*	Stem bark	Garcinisidone G	Stark *et al*., 2015a
5	*G. celebica*	Bark	Garcinisidone H	Bui *et al*., 2016
6	*G. cowa*	Twig	Cowadepsidone	Cheenpracha *et al*., 2011
7	*G. dulcis*	Stem bark	Garcinisidone A	Ito *et al*., 1997
8	*G. latissima*	Stem bark	Garcinisidone A	Ito *et al*., 1997
9	*G. neglecta*	Leaf	Garcinisidone B-F	Ito *et al*., 2001
10	*G. oliveri*	Bark	Oliveridepsidones A-D	Ha *et al*., 2012
11	*G. parvifolia*	Leaf	Garcidepsidone A, B, C, and D	Xu *et al*., 2000
			Garcidepsidone B	Rukachaisirikul *et al*., 2008
		Twig	Parvifolidones A, B	Rukachaisirikul *et al*., 2006
12	*G. puat*	Leaf	Garcinisidone B-F	Ito *et al*., 2001
13	*G. schomburgkiana*	Root	Schomburgdepsidones A, B	Sukandar *et al*., 2016a

5. Biphenyls

Biphenyls, reported as potential phytoalexins, are restricted to certain families and Clusiaceae is one among the families reported to contain biphenyls. Biphenyls are biosynthetically closely related to benzophenones and in a phylogenetic tree, biphenyl synthase (BIS) and benzophenone synthase (BPS) group together closely, indicating that they arise from a common ancestral gene. Biphenyl synthase (BIS) and benzophenone synthase (BPS) catalyze the formation of identical linear tetraketide intermediates from benzoyl-CoA (Beerhues and Liu, 2009).



Garcibiphenyl C **Schomburgbiphenyl** **3-hydroxy-4-geranyl-5-methoxybiphenyl**

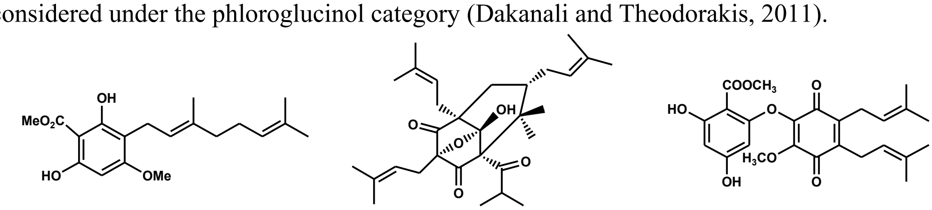
Figure 8. Structures of simple biphenyl (garcibiphenyl C), monoprenylated biphenyl (schomburgbiphenyl) and geranyl substituted biphenyl (3-hydroxy,4-geranyl,5-methoxy biphenyl)

Table 5. Biphenyls reported from *Garcinia* species

Sl. No.	*Garcinia* species	Plant part	Biphenyls	Reference
1	*G. bancana*	Twigs	[1,1'-Biphenyl]-2-(3-methyl-2-butenyl)-3-methoxy- 4,4',5,6-tetraol	Rukachaisirikul *et al*., 2005
2	*G. bracteata*	Twigs	Bractebiphenyls A-C, doitungbiphenyl A, doitungbiphenyl B, 2,2-dimethyl-3,5-dihydroxy-7-(4-hydroxyphenyl) chromane, oblongifoliagarcinine A, and schomburgbiphenyl	Li *et al*., 2015
3	*G. fucsa*	Root	Nigrolineabiphenyl B	Nontakham *et al*., 2014
4	*G. linii*	Root	Garcibiphenyl C, D and E	Chen *et al*., 2006
			Garcibiphenyl A and B	Chen *et al*., 2004
5	*G. mangostana*	Root bark	3-Hydroxy-4-geranyl-5-methoxybiphenyl	Dharmaratne *et al*., 2005
6	*G. multiflora*	Twig	Multiflorabiphenyls A and B	Xu *et al*., 2016a
		Leaf	Multiflorabiphenyls B-D	Fu *et al*., 2015
		Stem	Multiflorabiphenyls A-C	Gao *et al*., 2016
		Stem bark	Multiflorabiphenyls A	Jing *et al*., 2013
7	*G. nigrolineata*	Twig	Nigrolineabiphenyls A and B	Rukachaisirikul *et al.,* 2005a
8	*G. oblongifolia*	Leaf	Oblongifoliagarcinines A-D	Wu *et al*., 2008
9	*G. oligantha*	Stem	3-Methoxy-5-methoxycarbonyl-4-hydroxy biphenyl	Liu *et al*., 2015
10	*G. schomburkiana*	Wood	Schomburgbiphenyl	Mungmee *et al*.,2013
			Aucuparin, nigrolineabiphenyl B and Garcibiphenyl C	Mungmee *et al.,* 2012
		Stem	Schomburgbiphenyl A and B	Ito *et al*., 2013
11	*G. spp*	Twig	Doitungbiphenyls A and B	Siridechakorn *et al*., 2014
12	*G tetralata*	Twig	Tetralatabiphenyls A-C	Hu *et al*., 2016

6. Phloroglucinols

Phloroglucinols are an interesting group of phenolic compounds, based on a phloroglucinol or 1,3,5-benzenetriol skeleton. Phloroglucinols can be divided into subclasses such as acyl phloroglucinols, phloroglucinol glycosides and prenylated/geranylated phloroglucinols (Dakanali and Theodorakis, 2011). About 700 naturally occurring phloroglucinol compounds were reported, of which acylphloroglucinols (APGs) comprise the largest group of natural phloroglucinol compounds (Singh *et al*., 2010). Several *Garcinia* species have been reported to contain phloroglucinol derivatives (Zhou, *et al*., 2009). Benzophenones such as nemerosone and clusianone with close resemblance to phloroglucinol derivatives were also considered under the phloroglucinol category (Dakanali and Theodorakis, 2011).



Parvifoliol A Subellinone Atrovirinone

Figure 9. Structurs of monoprenylated phloroglucinol (parvifoliol A), polyprenylated phloroglucinol (subellinone) and phloroglucinic acid ester linked to a quinone moiety (atrovirinone)

Ultra performance liquid chromatography (UPLC) coupled with precursor ion discovery (PID) and tandem mass (MS/MS) scans has been reported as an efficient analytical tool for rapid screening of polycyclic polyprenylated acyl phloroglucinols from *Garcinia* species (Zhou, *et al*., 2009).

Phloroglucinol and its derivatives were reputed with biological activities such as antibacterial, cytotoxic, antiproliferative and antiangiogenic effects and have been widely used in medicine, cosmetics, pesticides, paints and dyes (Singh *et al*., 2010). The phloroglucinol Garsubellin A induces biosynthesis of acetylcholine, a neurotransmitter that at low concentrations can lead to Alzheimer's disease (Fukuyama *et al*., 1997).

Table 6. Phloroglucinols reported from *Garcinia* species

Sl. No.	*Garcinia* species	Plant part	Phloroglucinols	Reference
1	*G. atroviridis*	Root	Atrovirinone	Permana *et al*., 2001
2	*G. cowa*	Twig	Garcicowins A-D	Lin *et al*., 2010
3	*G. eugeniaefolia*	Stem bark	Enervosanone	Taher *et al*., 2007
4	*G. goudotiana*	Leaf	Goudotianone 1 and 2	Mahamodo *et al*., 2014
5	*G. multiflora*	Root	Garcinialone	Chien *et al*., 2008
6	*G. nujiangensis*	Leaf	Nujiangefolins A-C	Xia *et al*., 2012
7	*G. parvifolia*	Twig	Parvifoliols A-G	Rukachaisirikul *et al*., 2006
		Leaf	Parvifoliols B-E	Rukachaisirikul *et al*., 2008
8	*G. schomburgkiana*	Fruit	Oblongifolin C, garcicowin B, and garciyunnanin	Le *et al*., 2016
9	*G. subelliptica*	Heartwood	Garcinielliptone HF	Wu *et al*., 2008
			Garcinielliptone HA, HB, HC, HD, and HF	Lu *et al*., 2008
		Pericarp	Garcinielliptone FB	Wu *et al*., 2005
		Fruit	Garcinielliptone	Lin *et al*., 2005
		Wood	Subellinone	Fukuyama *et al*., 1993
			Garsubellins A	Fukuyama *et al*., 1997
			Garsubellins B-E	Fukuyama *et al*., 1998
			Cohulupone	Lin *et al*., 2010a
		Seed	Garcinielliptone A, B, C and D, and Garsubellins A	Weng *et al*., 2003
			Garcinielliptone K, L and M	Weng *et al*., 2004
			Garcinielliptone R	Lin *et al*., 2012
			Garcinielliptone P	Lin *et al*., 2010a
10	*G. verrucosa ssp orientalis*	Stem bark	Garcicosin	Rajaonarivelo *et al.,* 2009

7. Flavonoids

A variety of simple flavonoids such as quercetin, luteolin and apigenin were also reported from different *Garcinia* species.

Table 7. Flavonoids reported from *Garcinia* species

Sl. No.	*Garcinia* species	Plant part	Flavonoids	References
1	*G. andamanica*	Leaf	Scutellarein-7-diglucoside and sorbifolin-6-galactoside	Alam *et al*., 1986
			4′-Hydroxy wogonin 7-neohesperidoside	Alam *et al*., 1987
2	*G. bracteata*	Stem	Bracflavones A and B, quercetin, luteolin, apigenin, rhamnazin, and pilloin	Hu *et al*., 2014
			7-Methoxy-4',6-dihydroxy-8-isobutyryl-flavone	Li *et al*., 2015
		Twig	Bracteflavones A, bracteflavones, artocarmin D, 6-prenyl apigenin, cycloartocarpesin, and artochamin C	Yang *et al*., 2015
3	*G. brevipedicellata*	Stem bark	Pilloin	Ngoupayo *et al*., 2007
4	*G. celebica*	Stem bark	Epicatechin	Elfita *et al*., 2009
5	*G. conrauana*	Stem bark	Eriodictyol	Waterman and Chrichton, 1980
6	*G. cowa*	Stem	Quercetin	Shen *et al*., 2007
7	*G. dulcis*	Branch	3'-(3-Methyl-but-2-enyl) naringenin,	Harrison *et al*., 1994
		Ripe fruit	Dulcinoside, dulcisisoflavone, and dulcisflavan	Deachathai *et al*., 2005
8	*G. epunctata*	Stem bark	Taxifolin 6-C-glucoside	Mbafor *et al*., 1989
9	*G. eugenifolia*	Stem bark	Epicatechin	Taher *et al*., 2007
10	*G. gracilis*	Leaf	Apigenin-8-C-α-L-rhamnopyranosyl-(1→2)-β-D-glucopyranoside	Supasuteekul *et al*., 2016
11	*G. hombroniana*	Bark	3,3',4',5,5',7-Hexahydroxyflavone, 3,3',5,5',7-pentahydroxyflavanone, and 3,3',4',5,7-pentahydroxyflavone	Jamila *et al*., 2014
12	*G. kola*	Seed	Acacetin, apigenin-4'-5-7-trimethyl ether, and fisetin	Iwu and Igboko, 1982
			Naringin-7-rharmnoglucoseside	Okwu and Morah 2007
13	*G. livingstonei*	Seed	Eriodictyol	Srivastava and Sharma 1966
14	*G. mangostana*	Fruit hull	Taxifolin-3-o-α-L-rhamnoside	Huang *et al*., 2001
			Epicatechin	Yu *et al*., 2007
			Aromadendrin-8-C-glucopyranoside, and epicatechin	Abdallah *et al*., 2016
15	*G. multiflora*	Heart wood	Apigenin	Fa-Ching *et al*., 1975
16	*G. neglecta*	Leaf	Apigenin and narigenin	Ito *et al*., 2001
17	*G. nervosa*	Leaf	Nervosin, irigenin, and 7-methyl tectoirigenin	Ilyas *et al*., 1994
18	*G. parvifolia*	Leaf	Nigrolineaisoflavone A	Rukachaisirikul *et al*., 2008
19	*G. paucinervis*	Stem	Pauciisoflavone A	Hu *et al*., 2014
20	*G. purpurea*	Pericarp	Vitexin and apigenin-7-o-(6"-methyl ester)-glucuronide	Iinuma *et al*., 1996
21	*G. schomburgkiana*	Branch	Kaempferol, dihydrokaempferol and (-)-5,7,3′,5′-tetrahydroxyflavanone	Meechai *et al*., 2016
22	*G. vitiens*	Leaf	Vitexin	Parveen *et al*., 1994
23	*G.xipshuanbannaensis*	Fruit	Luteolin and 3ʹ,5,7-4ʹ-methoxy-flavone	Shen *et al*., 2006

Conclusions

Garcinia species are rich depository of structurally diverse secondary metabolites such as biflavonoids, prenylated and caged xanthones and polyisoprenylated benzophenones. Most of the *Garcinia* species are not yet explored for their chemical constituents or bioactivities. Literature survey revealed that, of the nearly 250 *Garcinia* species, less than 50% have been studied for their chemical constituents. Xanthones are the major class of phenolic compounds in *Garcinia* species, followed by benzophenones and biflavonoids. The chapter enlists the major phenolic compounds xanthones, benzophenones and biflavonoids, along with minor constituents biphenyls, despidones, phloroglucinols and simple flavonoids reported in *Garcinia* species world over.

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