CHAPTER II

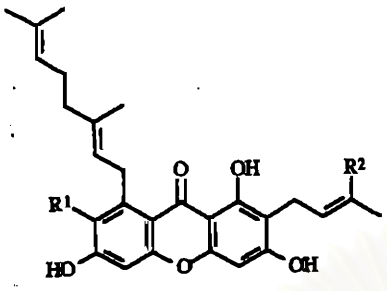
HISTORICAL

1. Chemical Constituents of Plants in the Genus *Garcinia*

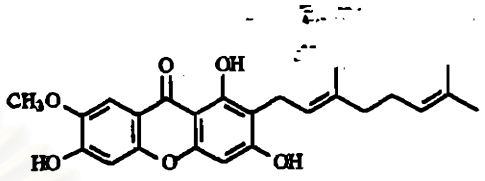
The chemical constituents reported for the plants in the genus *Garcinia* were xanthones, flavonoids, triterpenoids, steroids and several miscellaneous compounds. However, the two main groups are xanthones and flavonoids, as shown in Tables 1 and 2, respectively. Table 3 illustrates the distribution of other types of compounds.

Table 1 Distribution of xanthones in the genus *Garcinia*.

Plant and chemical compound	Plant part	Reference
Garcinia cowa		
Cowanin [1]	Latex	Na Pattalung *et al.*, 1994
Cowanol [2]	Latex	Na Pattalung *et al.*, 1994
Cowaxanthone [3]	Latex	Na Pattalung *et al.*, 1994
Norcowanin [4]	Latex	Na Pattalung *et al.*, 1994
1,3,6-Trihydroxy-7-methoxy-2,5-bis (3-methyl-2-butenyl)xanthone [5]	Latex	Na Pattalung *et al.*, 1994
1,3,6-Trihydroxy-7-methoxy-8-(3,7-dimethyl-2,6-octadienyl)xanthone [6]	Stem	Lee and Chan, 1977
G. densivenia		
Pyranojacareubin [7]	Bark	Waterman and Crichton, 1980a.
G. echinocarpa		
1,5-Dihydroxyxanthone [8]	Heartwood	Bandaranayake *et al.*,1975
1,3,6,7-Tetrahydroxyxanthone [9]	Bark	Bandaranayake *et al.*,1975
	Heartwood	Bandaranayake *et al.*,1975



[1] $R^1 = CH_3O$, $R^2 = H$
[2] $R^1 = CH_3O$, $R^2 = OH$
[3] $R^1 = OH$, $R^2 = H$



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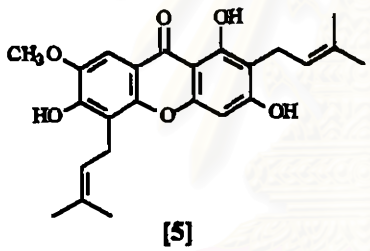

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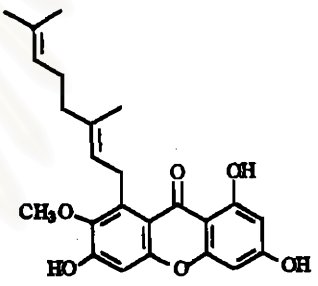
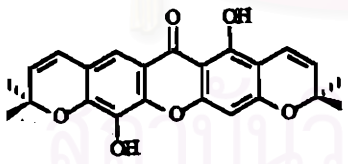


[6]



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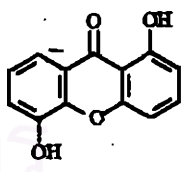

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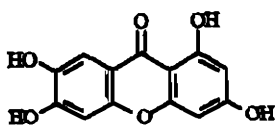

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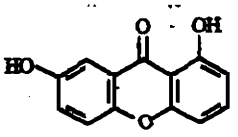
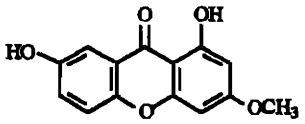


[10]

Table 1 (Continued)

Plant and chemical compound	Plant part	Reference
G. eugeniifolia		
1,7-Dihydroxyxanthone (Euxanthone) [10]	Heartwood	Jackson, Locksley and Scheinmann, 1969
1,7-Dihydroxy-3-methoxyxanthone (Gentisin) [11]	Heartwood	Jackson, Locksley and Scheinmann, 1969
1,5,6-Trihydroxyxanthone [12]	Heartwood	Jackson, Locksley and Scheinmann, 1969
1,6,7-Trihydroxyxanthone [13]	Heartwood	Jackson, Locksley and Scheinmann, 1969
1,4,7-Trihydroxy-3-methoxyxanthone [14]	Heartwood	Jackson, Locksley and Scheinmann, 1969
G. forbesii		
Forbexanthone [15]	Branch	Harrison *et al.*, 1993
Pyranojacareubin [7]	Branch	Harrison *et al.*, 1993
1,3,7-Trihydroxy-2-(3-methylbut-2-enyl)xanthone [16]	Branch	Harrison *et al.*, 1993
G. gerrardii		
Garcigerrin A [17]	Root bark	Sordat-Diserens *et al.*, 1989
Garcigerrin B [18]	Root bark	Sordat-Diserens *et al.*, 1989
12b-Hydroxy-des-D-garcigerrin A [19]	Root bark	Sordat-Diserens *et al.*, 1989
G. hanburyi		
Desoxygambogenin [20]	Resin	Asano *et al.*, 1996
Gambogellic acid [21]	Resin	Asano *et al.*, 1996
Gambogenic acid [22]	Resin	Asano *et al.*, 1996
Gambogenin [23]	Resin	Asano *et al.*, 1996
Gambogenin dimethyl acetal [24]	Resin	Asano *et al.*, 1996



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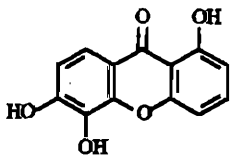

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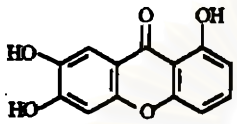

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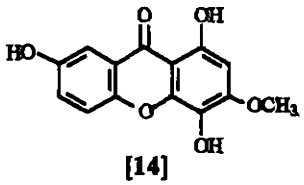

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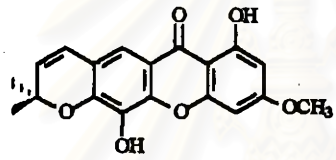

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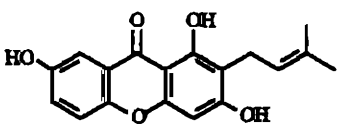

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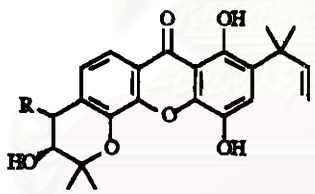
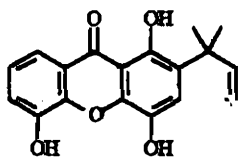


[17] R = β-OH
[18] R = α-OH



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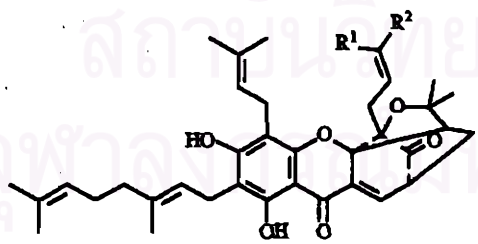
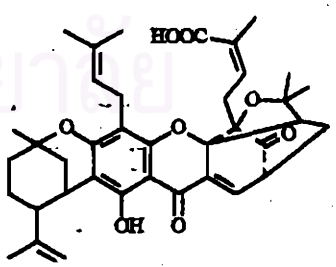


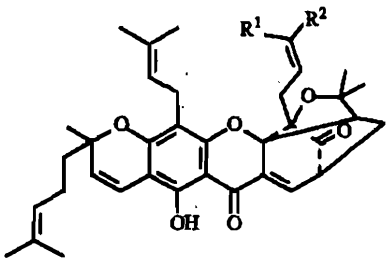
[20] $R^1 = CH_3$, $R^2 = CH_3$
[22] $R^1 = COOH$, $R^2 = CH_3$
[23] $R^1 = OHC$, $R^2 = CH_3$
[24] $R^1 = (OCH_3)_2HC$, $R^2 = CH_3$
[28] $R^1 = CH_3$, $R^2 = CHO$



[21]

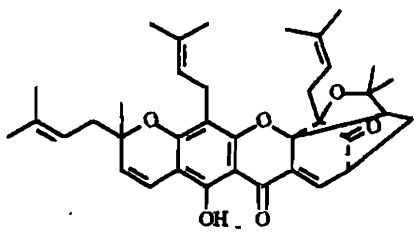
Table 1 (Continued)

Plant and chemical compound	Plant part	Reference
Gambogic acid [25]	Latex	Lin *et al.*, 1993; Asano *et al.*, 1996
Gambogin [26]	Resin	Asano *et al.*, 1996
Hanburin [27]	Resin	Asano *et al.*, 1996
Isogambogenin [28]	Resin	Asano *et al.*, 1996
Isogambogic acid [29]	Latex	Lin *et al.*, 1993; Asano *et al.*, 1996
Isomorellinol [30]	Latex	Lin *et al.*, 1993; Asano *et al.*, 1996
Isomoreollin B [31]	Resin	Asano *et al.*, 1996
Morellin dimethyl acetal [32]	Resin	Asano *et al.*, 1996
Moreollic acid [33]	Resin	Asano *et al.*, 1996
G. indica		
1,7-Dihydroxyxanthone (Euxanthone) [10]	Heartwood	Cotterill, Scheinmann and Puranik, 1977
G. livingstonei		
6,11-Dihydroxy-2,2-dimethylpyrano [3,2-C]xanthen-7(2H)-one [34]	Root bark	Sordat-Diserens, Rogers *et al.*, 1992
6,11-Dihydroxy-3-methyl-3-(4-methyl pent-3-enyl)-3H,7H-pyrano[2,3-C] xanthen-7-one [35]	Root bark	Sordat-Diserens, Rogers *et al.*, 1992
4-(3′,7′-Dimethylocta-2′,6′-dienyl)-1,3,5-trihydroxy-9H-xanthen-9-one [36]	Root bark	Sordat-Diserens, Rogers *et al.*,1992
Garcilivin A [37]	Root bark	Sordat-Diserens, Hamburger *et al.*,1992
Garcilivin B [38]	Root bark	Sordat-Diserens, Hamburger *et al.*,1992

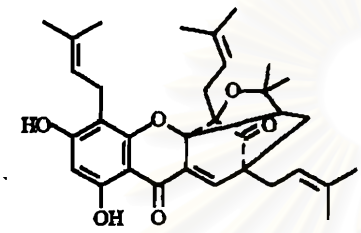


[25] $R^1 = COOH$, $R^2 = CH_3$

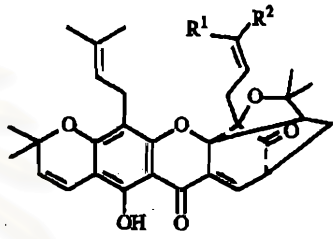
[29] $R^1 = CH_3$, $R^2 = COOH$



[26]

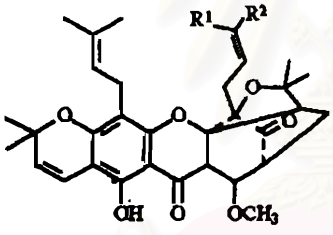


[27]



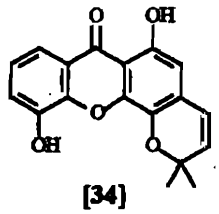
[30] $R^1 = CH_3$, $R^2 = CH_2OH$

[32] $R^1 = (CH_3O)_2HC$, $R^2 = CH_3$



[31] $R^1 = CH_3$, $R^2 = CHO$

[33] $R^1 = COOH$, $R^2 = CH_3$



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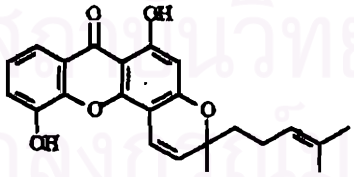

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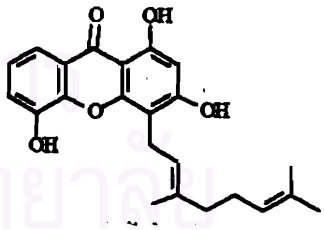

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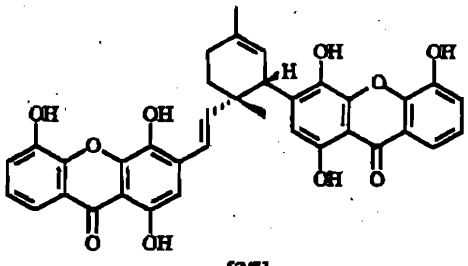

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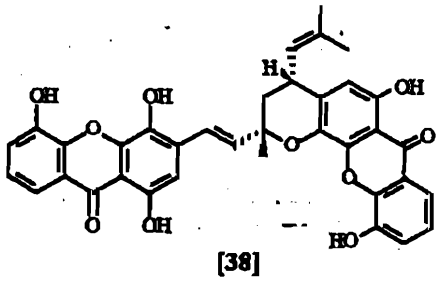
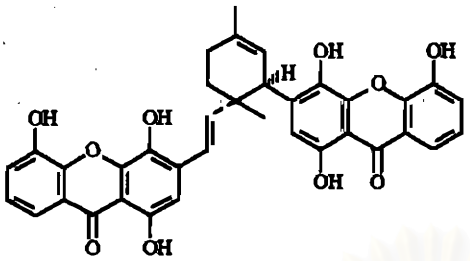


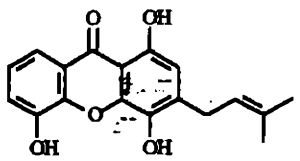
[38]

Table 1 (Continued)

Plant and chemical compound	Plant part	Reference
Garcilivin C [39]	Root bark	Sordat-Diserens, Hamburger *et al.*,1992
12b-Hydroxy-des-D-garcigerrin A [19]	Root bark	Sordat-Diserens, Rogers *et al.*, 1992
1,4,5-Trihydroxy-3-(3-methylbut-2-enyl)-9H-xanthene-9-one [40]	Root bark	Sordat-Diserens, Rogers *et al.*,1992
G. mangostana		
2,8-bis-(γ,γ-Dimethylallyl)-1,3,7-trihydroxyxanthone [41]	Arils	Mahabusarakam, Wiriyachitra and Taylor, 1987
BR-Xanthone A [42]	Fruit hulls	Balasubramanian and Rajagopalan, 1988
BR-Xanthone B [43]	Fruit hulls	Balasubramanian and Rajagopalan, 1988
Calabaxanthone [44]	Arils	Mahabusarakam, Wiriyachitra and Taylor, 1987
Demethylcalabaxanthone [45]	Arils	Mahabusarakam, Wiriyachitra and Taylor, 1987
8-Deoxygartanin [46]	Fruit hulls	Govindachari *et al.*, 1971; Sakai *et al.*, 1993
6-Deoxy-γ-mangostin [47]	Fruit hulls	Sakai *et al.*, 1993
1,6-Dihydroxy-3-methoxy-2-(3-methyl-2-butenyl)xanthone [48]	Leaf	Parveen and Khan, 1988
5,9-Dihydroxy-8-methoxy-2,2-dimethyl-7-(3-methylbut-2-enyl)-2H, 6H-pyrano[3,2-b]xanthen-6-one [49]	Fruit hull	Sen *et al.*, 1980



[39]



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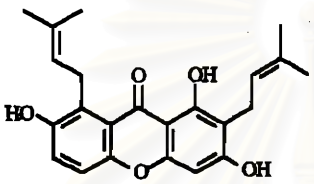

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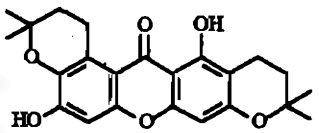

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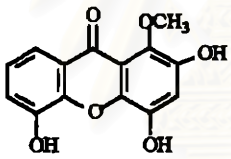

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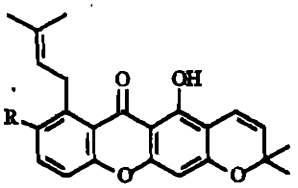
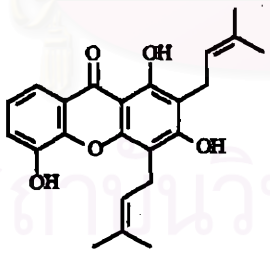


[44] R = CH_3O
[45] R = OH



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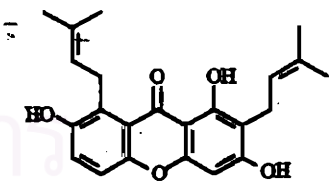

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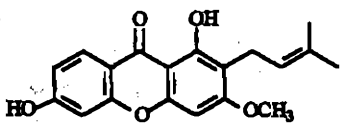

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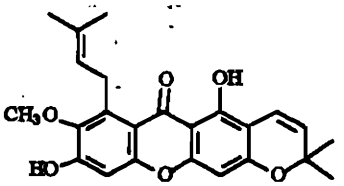
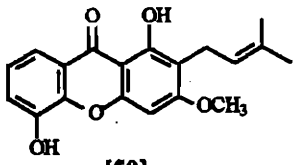


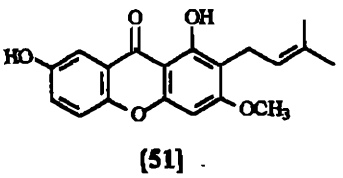
[49]

Table 1 (Continued)

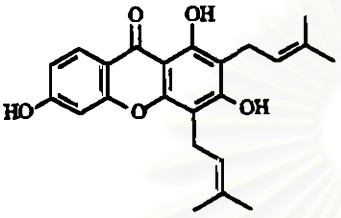
Plant and chemical compound	Plant part	Reference
1,5-Dihydroxy-2-(3-methylbut-2-enyl) -3-methoxyxanthone [50]	Fruit hulls	Sen *et al.*, 1981; Asai *et al.*, 1995
1,7-Dihydroxy-2-(3-methylbut-2-enyl) -3-methoxyxanthone [51]	Fruit hulls	Sen *et al.*, 1981; Asai *et al.*, 1995
	Arils	Mahabusarakam, Wiriyachitra and Taylor, 1987
Garcinone A [52]	Fruit hulls	Sen *et al.*, 1982
Garcinone B [53]	Fruit hulls	Sen *et al.*, 1982; Sakai *et al.*, 1993
Garcinone C [54]	Fruit hulls	Sen *et al.*, 1982
Garcinone D [55]	Fruit hulls	Sen *et al.*, 1986
Garcinone E [56]	Fruit hulls	Asai *et al.*, 1995, Sakai *et al.*, 1993
Gartanin [57]	Fruit hulls	Govindachari, 1971; Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.* 1995
	Leaf	Parveen and Khan, 1988
1-Isomangostin [58]	Fruit hulls	Mahabusarakam, Wiriyachitra and Taylor, 1987
3-Isomangostin [59]	Fruit hulls	Mahabusarakam, Wiriyachitra and Taylor, 1987
1-Isomangostin hydrate [60]	Fruit hulls	Mahabusarakam, Wiriyachitra and Taylor, 1987



[50]



[51]



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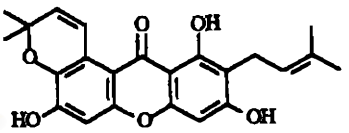
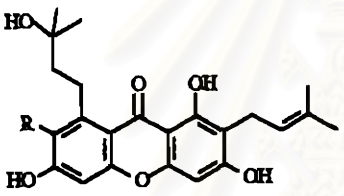
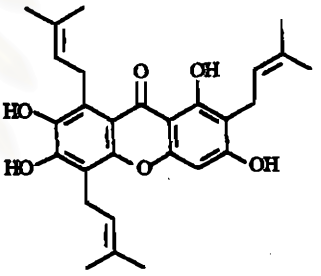


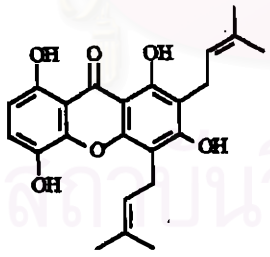
[53]



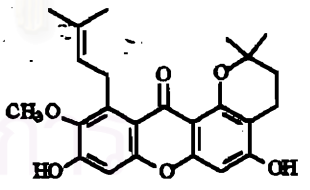
[54] R = OH
[55] R = OCH_3



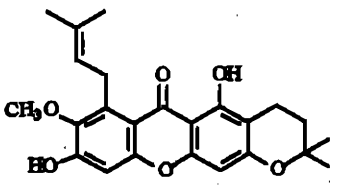
[56]



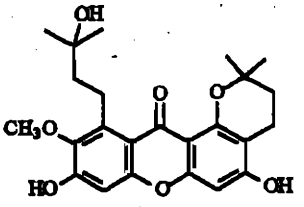
[57]



[58]



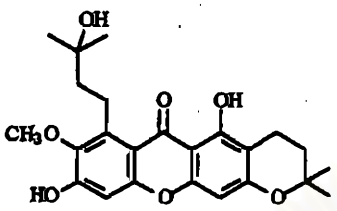
[59]



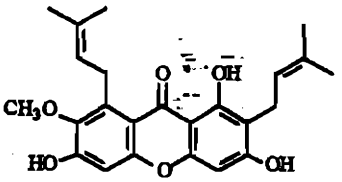
[60]

Table 1 (Continued)

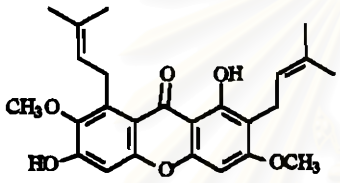
Plant and chemical compound	Plant part	Reference
3-Isomangostin hydrate [61]	Fruit hulls	Mahabusarakam, Wiriyachitra and Taylor, 1987
α-Mangostin [62]	Arils	Mahabusarakam, Wiriyachitra and Taylor, 1987
	Fruit hulls	Yates and Stout, 1958; Sen *et al.*, 1981; Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.*, 1995
β-Mangostin [63]	Fruit hulls	Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.*, 1995
γ-Mangostin [64]	Fruit hulls	Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.*, 1995
Mangostinone [65]	Fruit hulls	Asai *et al.*, 1995
1,3,6,7-Tetrahydroxyxanthone [9]	Heartwood	Holloway and Scheinmann, 1975
1,3,6,7-Tetrahydroxyxanthone-*O*-β-D-glucoside [66]	Heartwood	Holloway and Scheinmann, 1975
1,5,8-Trihydroxy-3-methoxy-2(3-methyl-2-butenyl)xanthone [67]	Leaf	Parveen and Khan, 1987; Parveen and Khan, 1988
	Fruit hulls	Sakai *et al.*, 1993



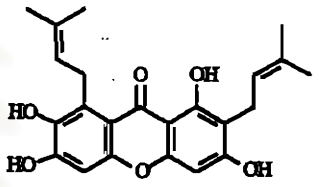
[61]



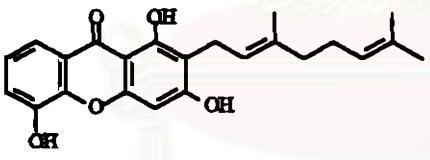
[62]



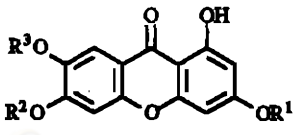
[63]



[64]

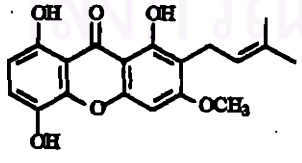


[65]

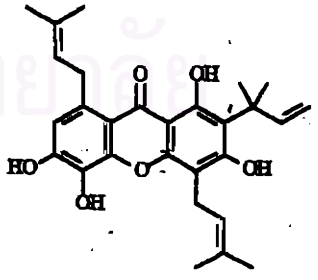


R^1, R^2, R^3 = H, H, Glucose
or R^1, R^2, R^3 = H, Glucose, H
or R^1, R^2, R^3 = Glucose, H, H

[66]



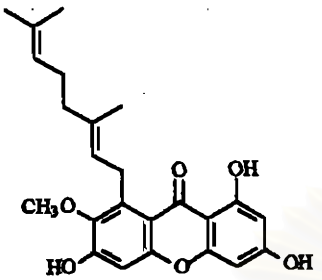
[67]



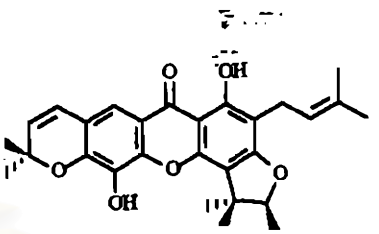
[68]

Table 1 (Continued)

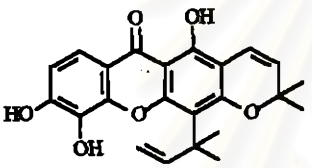
Plant and chemical compound	Plant part	Reference
G. multiflora		
1,3,6,7-Tetrahydroxyxanthone [9]	Heartwood	Chen, Lin and Hung, 1975a
G. nervosa		
Nervosaxanthone [68]	Bark	Ampofo and Waterman, 1986
Rubraxanthone [69]	Bark	Ampofo and Waterman, 1986
G. opaca		
4″,5″-Dihydro-1,5-dihydroxy-6′,6′-dimethylpyrano(2′,3′:6,7)-2-(3-methyl but-2-enyl)-4″,4″,5″-trimethylfurano (2″,3″:3,4)xanthone [70]	Leaf	Goh *et al.*, 1992
Macluraxanthone [71]	Leaf	Goh *et al.*, 1992
1,3,5-Trihydroxy-6′,6′-dimethylpyrano (2′,3′:6,7)-4-(1,1-dimethylprop-2-enyl)xanthone [72]	Leaf	Goh *et al.*, 1992
1,3,5-Trihydroxy-6′,6′-dimethylpyrano (2′,3′:6,7)-2-(3-methylbut-2-enyl)-4-(1,1-dimethylprop-2-enyl)xanthone [73]	Leaf	Goh *et al.*, 1992
G. ovalifolia		
Macluraxanthone [71]	Bark	Waterman and Crichton, 1980b
Garcinia pedunculata		
1,3,5,7-Tetrahydroxyxanthone [74]	Heartwood	Rao *et al.*, 1974
1,3,6,7-Tetrahydroxyxanthone [9]	Heartwood	Rao *et al.*, 1974



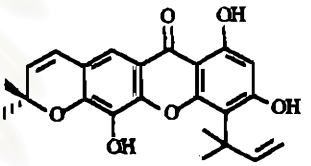
[69]



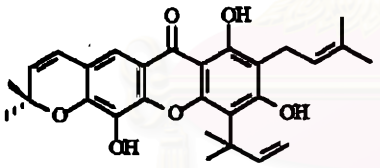
[70]



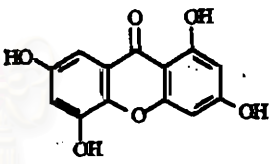
[71]



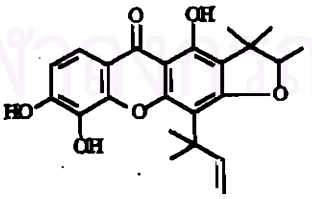
[72]



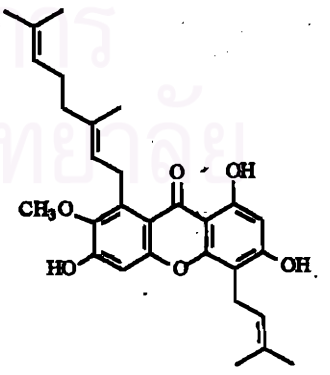
[73]



[74]



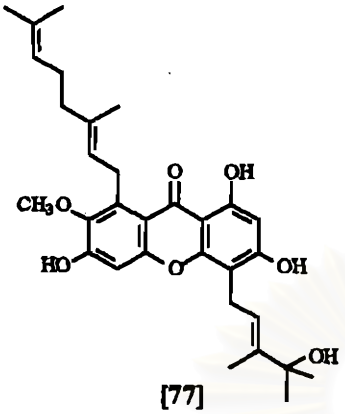
[75]



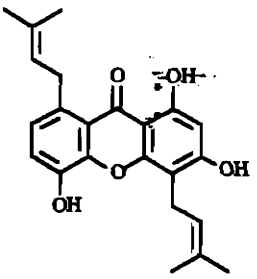
[76]

Table 1 (Continued)

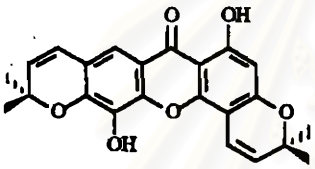
Plant and chemical compound	Plant part	Reference
G. polyantha		
Isorheediaxanthone B [75]	Bark	Ampofo and Waterman, 1986
G. pyrifera		
Isocowanin [76]	Bark	Ampofo and Waterman, 1986
Isocowanol [77]	Bark	Ampofo and Waterman, 1986
Rubraxanthone [69]	Bark	Ampofo and Waterman, 1986
G. quadrifaria		
1,3,5-Trihydroxy-4,8-di(3′,3′-dimethyl allyl)xanthone [78]	Bark	Waterman and Hussain, 1982
G. staudtii		
Rheediaxanthone-A [79]	Bark	Waterman and Hussain, 1982
G. subelliptica		
1,5-Dihydroxyxanthone [8]	Heartwood	Minami *et al.*, 1994
1,2-Dihydroxy-5,6-dimethoxyxanthone [80]	Heartwood	Minami *et al.*, 1994
2,6-Dihydroxy-1,5-dimethoxyxanthone [81]	Heartwood	Minami *et al.*, 1994
1,5-Dihydroxy-3-methoxyxanthone [82]	Root bark	Iinuma *et al.* ,1995a
1,6-Dihydroxy-5-methoxyxanthone [83]	Heartwood	Minami *et al.*, 1994
1,8-Dihydroxy-6-methoxyxanthone [84]	Heartwood	Minami *et al.*, 1994



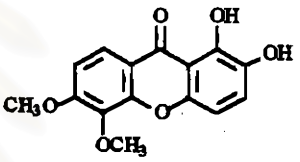
[77]



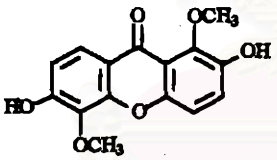
[78]



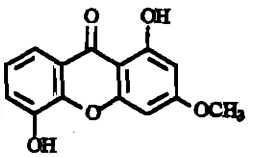
[79]



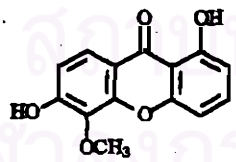
[80]



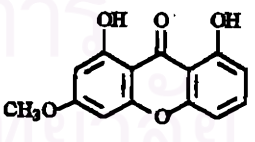
[81]



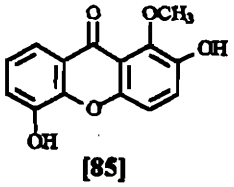
[82]



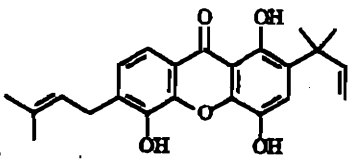
[83]



[84]



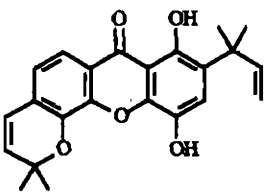
[85]



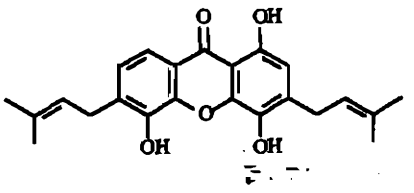
[86]

Table 1 (Continued)

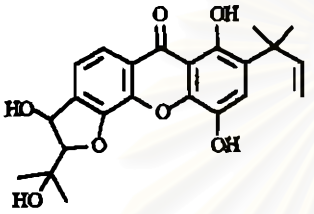
Plant and chemical compound	Plant part	Reference
2,5-Dihydroxy-1-methoxyxanthone [85]	Heartwood	Minami *et al.*, 1996
Garciniaxanthone A [86]	Heartwood	Fukuyama *et al.*, 1991; Minami *et al.*, 1994
Garciniaxanthone B [87]	Heartwood	Fukuyama *et al.*, 1991; Minami *et al.*, 1994
Garciniaxanthone C [88]	Heartwood	Minami *et al.*, 1994
Garciniaxanthone D [89]	Heartwood	Minami *et al.*, 1995
Garciniaxanthone E [90]	Heartwood	Minami *et al.*, 1996
Globuxanthone [91]	Heartwood	Fukuyama *et al.*, 1991; Minami *et al.*, 1994
	Rootbark	Iinuma *et al.*, 1995b
12b-Hydroxy-des-D-garcigerin A [19]	Heartwood	Fukuyama *et al.*, 1991
	Root bark	Iinuma *et al.*, 1995b
1-*O*-Methylsymphoxanthone [92]	Heartwood	Minami *et al.*, 1996
Subelliptenone A [93]	Root bark	Iinuma *et al.*, 1994,
	Heartwood	Minami *et al.*, 1996
Subelliptenone B [94]	Root bark	Iinuma *et al.*, 1994
Subelliptenone C [95]	Root bark	Iinuma *et al.*, 1995b
Subelliptenone D [96]	Root bark	Iinuma *et al.*, 1995b
Subelliptenone E [97]	Root bark	Iinuma *et al.*, 1995a
Subelliptenone F [98]	Root bark	Iinuma *et al.*, 1995a
Subelliptenone G [99]	Root bark	Iinuma *et al.*, 1995a,
	Heartwood	Minami *et al.*, 1995
Subelliptenone H [100]	Root bark	Iinuma *et al.*, 1995c
Subelliptenone I [101]	Root bark	Iinuma *et al.*, 1995c
Symphoxanthone [102]	Heartwood	Minami *et al.*, 1996
1,2,5-Trihydroxyxanthone [103]	Heartwood	Minami *et al.*, 1994



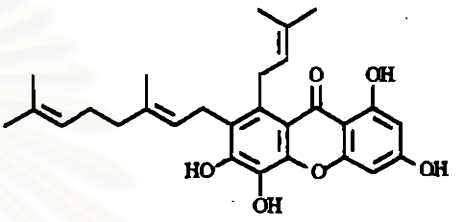
[87]



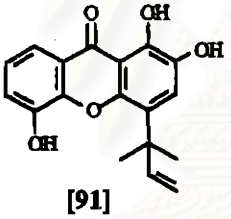
[88]



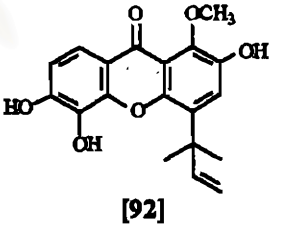
[89]



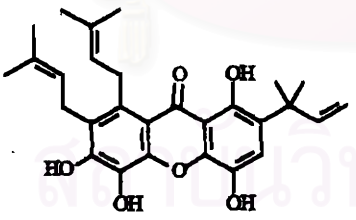
[90]



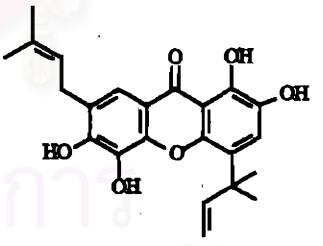
[91]



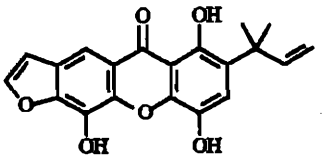
[92]



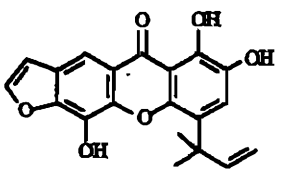
[93]



[94]



[95]



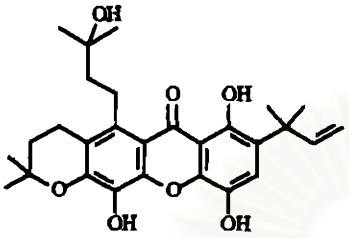
[96]

Table 1 (Continued)

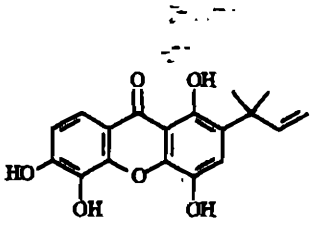
Plant and chemical compound	Plant part	Reference
G. terpnophylla		
1,5-Dihydroxyxanthone [8]	Heartwood	Bandaranayake *et al.*, 1975
α-Mangostin [61]	Bark	Bandaranayake *et al.*, 1975
	Heartwood	Bandaranayake *et al.*, 1975
G. thwaitesii		
2,5-Dihydroxy-1,6-dimethoxyxanthone [104]	Bark and timber	Gunatilaka *et al.*, 1983

Table 2 Distribution of flavonoids in the genus *Garcinia*

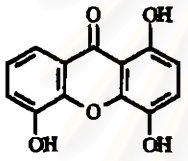
Plant and chemical compound	Plant part	Reference
G. andamanica		
Scutellarein-7-diglucoside [105]	Leaf	Alam *et al.*, 1986
Sorbifolin-6-galactoside [106]	Leaf	Alam *et al*, 1986
4'-Hydroxywogonin-7-neohesperidoside [107]	Leaf	Alam, Kamil and Ilyas, 1987
G. buchananii		
Biflavanone GB-1 [108]	Heartwood	Jackson *et al.*, 1971
Biflavanone GB-1a [109]	Heartwood	Jackson *et al.*, 1971
Biflavanone GB-2 [110]	Heartwood	Jackson *et al.*, 1971
Biflavanone GB-2a [111]	Heartwood	Jackson *et al.*, 1971
G. conrauana		
Eriodictyol [112]	Bark	Waterman and Crichton, 1980c; Hussain and Waterman, 1982
	Leaf	Hussain and Waterman, 1982



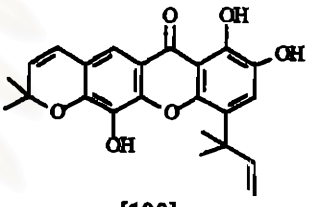
[97]



[98]



[99]



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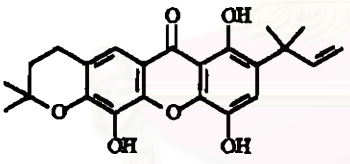
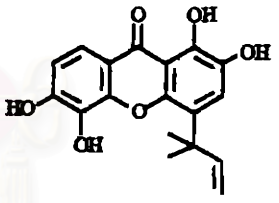
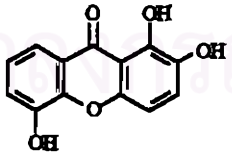


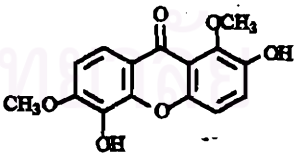
[101]



[102]



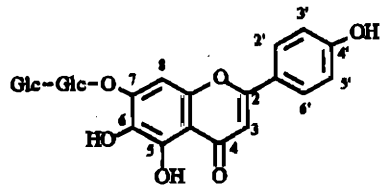
[103]



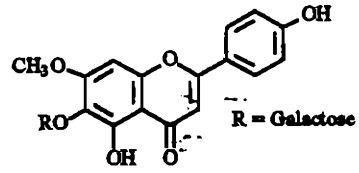
[104]

Table 2 (Continued)

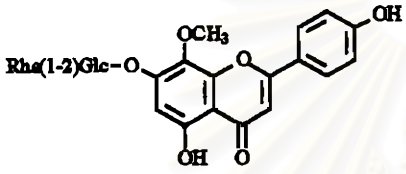
Plant and chemical compound	Plant part	Reference
	Seed	Hussain and Waterman, 1982
Manniflavanone [113]	Leaf	Hussain and Waterman, 1982
O-Methylfukugetin [114]	Heartwood	Hussain and Waterman, 1982
Morelloflavone (Fukugetin) [115]	Heartwood	Hussain and Waterman, 1982
G. densivenia		
Morelloflavone (Fukugetin) [115]	Bark	Waterman and Crichton, 1980a
O-Methylfukugetin [114]	Bark	Waterman and Crichton, 1980a
G. echinocarpa		
Morelloflavone (Fukugetin) [115]	Bark	Bandaranayake *et al.*, 1975
	Heartwood	Bandaranayake *et al.*, 1975
Volkensiflavone (Talbotaflavone) [116]	Bark	Bandaranayake *et al.*, 1975
	Heartwood	Bandaranayake *et al.*, 1975
G. epunctata		
Taxifolin-6-*C*-glucoside [117]	Bark	Mbafor and Fomum, 1989
G. eugeniifolia		
Biflavanone GB-1 [108]	Heartwood	Jackson, Locksley and Scheinmann, 1969



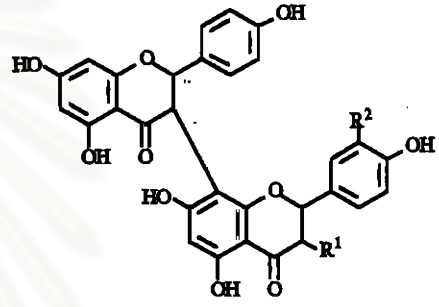
[105]



[106]



[107]

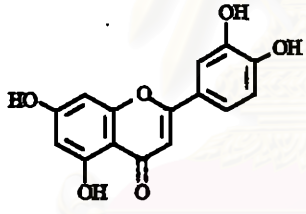


[108] $R^1 = OH, R^2 = H$

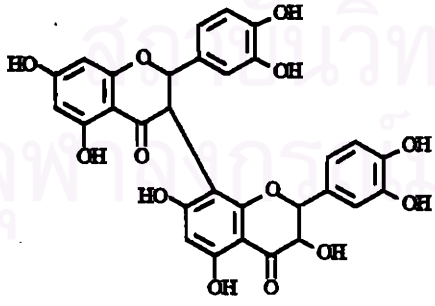
[109] $R^1 = H, R^2 = H$

[110] $R^1 = OH, R^2 = OH$

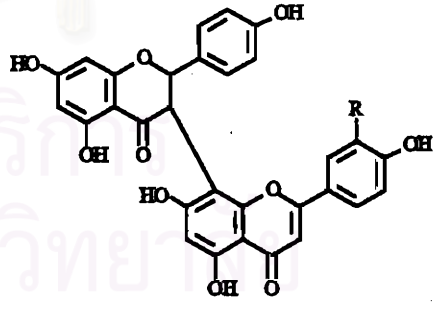
[111] $R^1 = H, R^2 = OH$



[112]



[113]



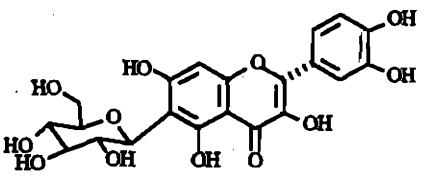
[114] R= OCH_3

[115] R = OH

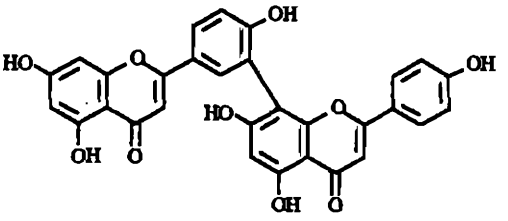
[116] R = H

Table 2 (Continued)

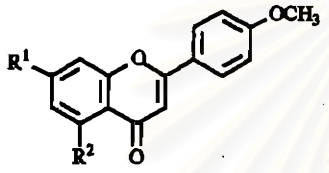
Plant and chemical compound	Plant part	Reference
Biflavanone GB-1a [109]	Heartwood	Jackson, Locksley and Scheinmann, 1969
Biflavanone GB-2 [110]	Heartwood	Jackson, Locksley and Scheinmann, 1969
Biflavanone GB-2a [111]	Heartwood	Jackson, Locksley and Scheinmann, 1969
G. indica		
Morelloflavone (Fukugetin) [115]	Heartwood	Cotterill, Scheinmann and Puranik, 1977
Volkensiflavone (Talbotaflavone) [116]	Heartwood	Cotterill, Scheinmann and Puranik, 1977
G. kola		
Amentoflavone [118]	Seed	Iwu and Igboko, 1982
4′-Methylapigenin [119]	Seed	Iwu and Igboko, 1982
4′,5,7-Trimethylapigenin [120]	Seed	Iwu and Igboko, 1982
Biflavanone GB-1 [108]	Seed	Cotterill and Scheinman, 1978; Iwu and Igboko, 1982
	Bark	Kabangu *et al.*, 1987
Biflavanone GB-1a [109]	Seed	Cotterill and Scheinmann, 1978
Biflavanone GB-2 [110]	Seed	Cotterill and Scheinmann, 1978
	Bark	Kabangu *et al.*, 1987
Biflavanone GB-3 [121]	Bark	Kabangu *et al.*, 1987
Fisetin [122]	Seed	Iwu and Igboko, 1982
Kolaflavanone [123]	Seed	Iwu and Igbogo, 1982; Cotterill and Scheinmann, 1978



[117]

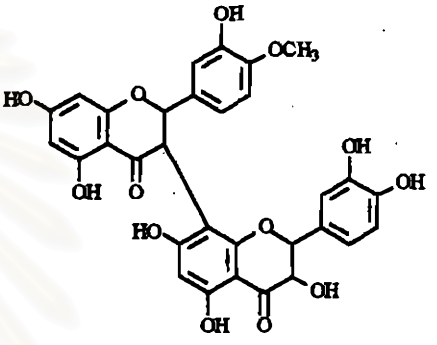


[118]

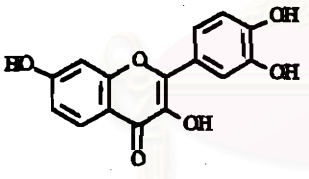


[119] $R^1 = OH, R^2 = OH$

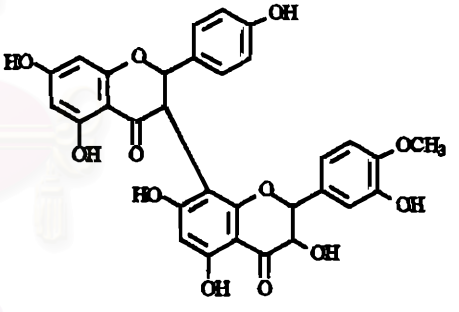
[120] $R^1 = OCH_3, R^2 = OCH_3$



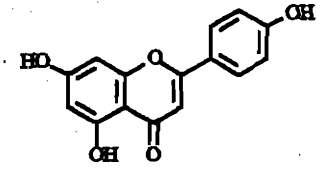
[121]



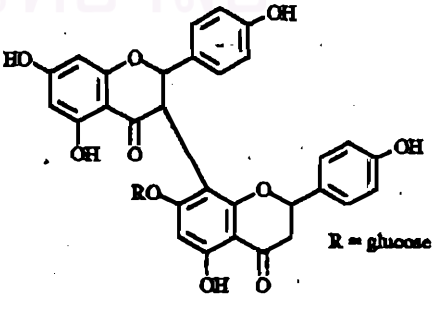
[122]



[123]



[124]



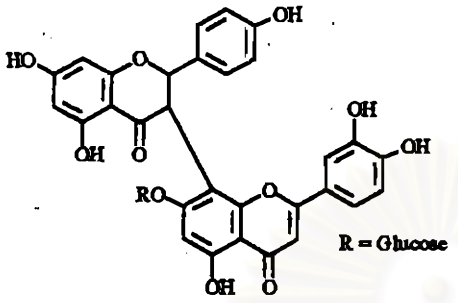
[125]

Table 2 (Continued)

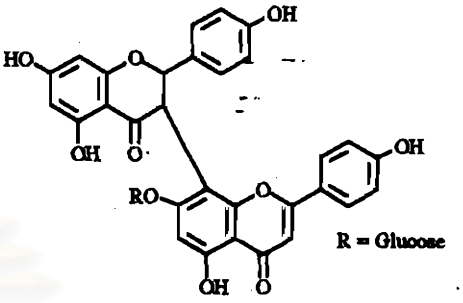
Plant and chemical compound	Plant part	Reference
G. mannii		
Biflavanone GB-1 [108]	Bark	Crichton and Waterman, 1979; Hussain and Waterman, 1982
	Heartwood	Hussain and Waterman, 1982
	Leaf	Hussain and Waterman, 1982
Biflavanone GB-1a [109]	Heartwood	Hussain and Waterman, 1982
	Bark	Crichton and Waterman, 1979
Biflavanone GB-2 [110]	Bark	Crichton and Waterman, 1979; Hussain and Waterman, 1982
	Heartwood	Hussain and Waterman, 1982
	Leaf	Hussain and Waterman, 1982
Biflavanone GB-2a [111]	Bark	Crichton and Waterman, 1979
Manniflavanone [113]	Bark	Crichton and Waterman, 1979; Hussain and Waterman, 1982
	Heartwood	Hussain and Waterman, 1982
	Leaf	Hussain and Waterman, 1982

Table 2 (Continued)

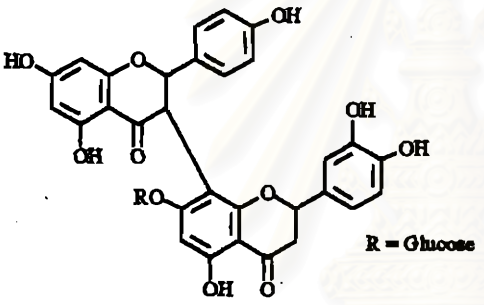
Plant and chemical compound	Plant part	Reference
Kolaflavanone [123]	Bark	Crichton and Waterman, 1979
G. morella		
Morelloflavone (Fukugetin) [115]	Heartwood	Karanjgaokar, Radhakrishnan and Venkataraman, 1967
G. multiflora		
Apigenin [124]	Heartwood	Chen, Lin and Hung, 1975a
Biflavanone GB-1a [109]	Heartwood	Chen, Lin and Hung, 1975a
Biflavanone GB-2a [111]	Heartwood	Chen, Lin and Hung, 1975a
3,8″-Binaringenin-7″-*O*-β-glucoside (GB-1a glucoside) [125]	Heartwood	Chen, Lin and Hung, 1975b
Fukugiside [126]	Heartwood	Chen, Lin and Hung, 1975b
Morelloflavone (Fukugetin) [115]	Heartwood	Chen, Lin and Hung, 1975a
Spicataside [127]	Heartwood	Chen, Lin and Hung, 1975b
Volkensiflavone (Talbotaflavone) [116]	Heartwood	Chen, Lin and Hung, 1975a
Xanthochymuside [128]	Heartwood	Chen, Lin and Hung, 1975b
Garcinia nervosa		
I-5-II-5-I-7-II-7-I-3′-I-4′-II-4′-Hepta hydroxy-[I-3-II-8]-flavanonylflavone [129]	Leaf	Babu *et al.*, 1988



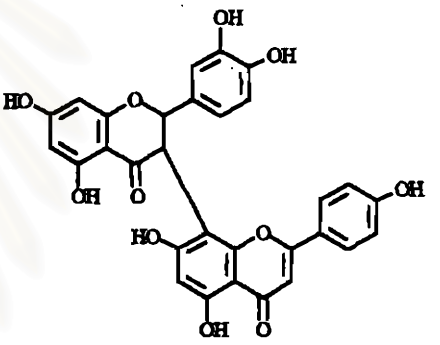
[126]



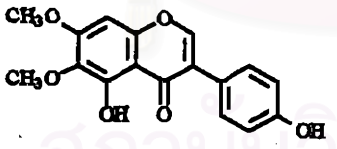
[127]



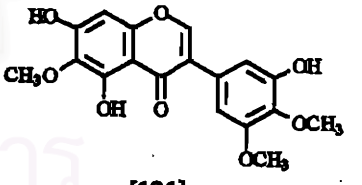
[128]



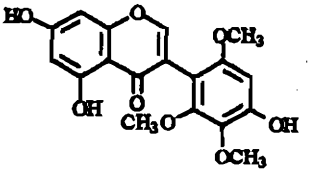
[129]



[130]



[131]



[132]

Table 2 (Continued)

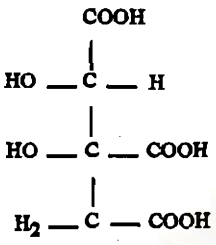
Plant and chemical compound	Plant part	Reference
7-Methyltectorigenin [130]	Leaf	Ilyas *et al.*, 1994
Irigenin [131]	Leaf	Ilyas *et al.*, 1994
Nervosin [132]	Leaf	Ilyas *et al.*, 1994
G. pedunculata		
Biflavanone GB-1a [109]	Heartwood	Rao *et al.*, 1974
Volkensiflavone (Talbotaflavone) [116]	Heartwood	Rao *et al.*, 1974
G. polyantha		
Xanthochymuside [128]	Bark	Ampofo and Waterman, 1986
G. quadrifaria		
O-Methylfukugetin [114]	Bark	Waterman and Hussain, 1982
	Seed	Waterman and Hussain, 1982
Morelloflavone (Fukugetin) [115]	Bark	Waterman and Hussain, 1982
	Seed	Waterman and Hussain, 1982
G. spicata		
Biflavanone GB-1 [108]	Leaf	Gunatilaka *et al.*, 1984
Biflavanone GB-1a [109]	Leaf	Gunatilaka *et al.*, 1984
Biflavanone GB-2 [110]	Leaf	Gunatilaka *et al.*, 1984
Biflavanone GB-2a [111]	Leaf	Gunatilaka *et al.*, 1984
Morelloflavone (Fukugetin) [115]	Leaf	Gunatilaka *et al.*, 1984
G. terpnophylla		
Biflavanone GB-1 [108]	Bark	Bandaranayake *et al.*, 1975

Table 2 (Continued)

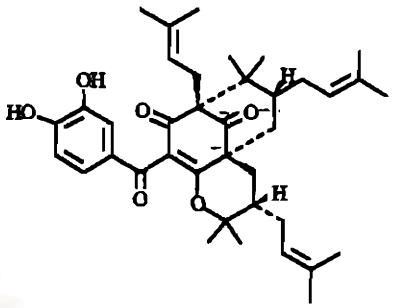
Plant and chemical compound	Plant part	Reference
	Heartwood	Bandaranayake *et al.*, 1975
Biflavanone GB-1a [109]	Bark	Bandaranayake *et al.*, 1975
	Heartwood	Bandaranayake *et al.*, 1975
Biflavanone GB-2 [110]	Bark	Bandaranayake *et al.*, 1975
	Heartwood	Bandaranayake *et al.*, 1975
G. thwaitesii		
Biflavanone GB-1 [108]	Bark and timber	Gunatilaka *et al.*, 1983
Biflavanone GB-1a [109]	Bark and timber	Gunatilaka *et al.*, 1983
Biflavanone GB-2 [110]	Bark and timber	Gunatilaka *et al.*, 1983
Biflavanone GB-2a [111]	Bark and timber	Gunatilaka *et al.*, 1983

Table 3 Distribution of miscellaneous compounds in the genus *Garcinia*

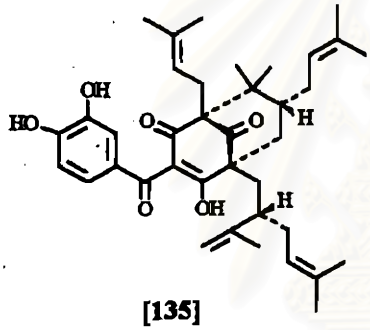
Plant and chemical compound	Category	Plant part	Reference
G. atroviridis			
Hydroxycitric acid [133]	Organic acid	Fruit	Lewis and Neelakantan, 1965
G. cambogia			
Cambogin [134]	Benzenoid	Latex	Rao, Venkatswamy and Pendse, 1980
Hydroxycitric acid [133]	Organic acid	Fruit	Lewis and Neelakantan, 1965
Garcinol [135]	Benzenoid	Latex	Rao, Venkatswamy and Pendse, 1980
G. conrauana			
5,7-Dihydroxychromone [136]	Chromone	Bark	Waterman and Crichton, 1980c; Hussain and Waterman, 1982
		Leaf	Hussain and Waterman, 1982
Conrauanalactone [137]	Lactone	Bark	Waterman and Crichton, 1980c
		Leaf	Hussain and Waterman, 1982
3-(3″,3″-Dimethylallyl) conrauanalactone [138]	Lactone	Bark	Hussain and Waterman, 1982
		Seed	Hussain and Waterman, 1982
		Leaf	Hussain and Waterman, 1982



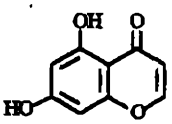
[133]



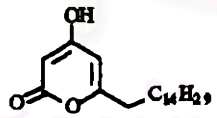
[134]



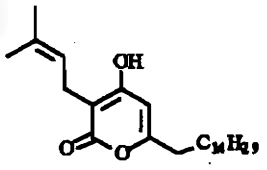
[135]



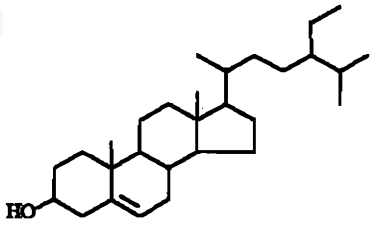
[136]



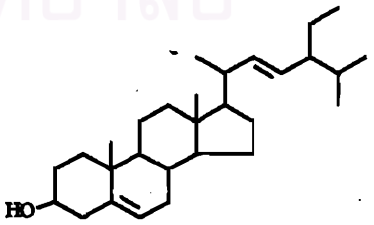
[137]



[138]



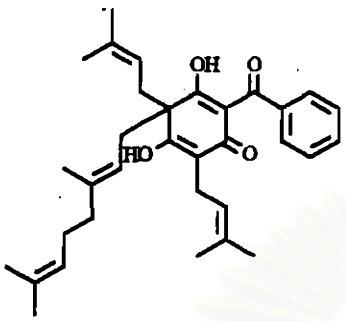
[139]



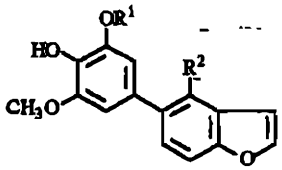
[140]

Table 3 (Continued)

Plant and chemical compound	Category	Plant part	Reference
G. echinocarpa			
β-Sitosterol [139]	Steroid	Heartwood	Bandaranayake *et al.*, 1975
G. huillensis			
Garcinol [135]	Benzenoid	Bark	Bakana *et al.*, 1987
β-Sitosterol [139]	Steroid	Bark	Bakana *et al.*, 1987
Stigmasterol [140]	Steroid	Bark	Bakana *et al.*, 1987
G. indica			
Hydroxycitric acid [133]	Organic acid	Fruit	Lewis and Neelakantan, 1965
Garcinol [135]	Benzenoid	Fruitpeel	Krishnaumurthy, Lewis and Ravindranath, 1981
G. kola			
Kolanone [141]	Benzenoid	Fruit pulp	Hussain *et al.*, 1982
Garcinol [142]	Benzenoid	Root	Niwa, Terashima and Aqil, 1993
Cycloartenol [143]	Benzenoid	Seed	Aplin *et al.*, 1967; Cotterill and Scheinmann, 1978
Garcipyran [144]	Benzenoid	Root	Niwa, Ito, *et al.*, 1994
Garcifuran A [142]	Benzenoid	Root	Niwa, Terashima *et al.*, 1994
Garcifuran B [145]	Benzenoid	Root	Niwa, Terashima *et al.*, 1994
24-Methylenecycloartenol [146]	Benzenoid	Seed	Aplin *et al.*, 1967; Cotterill and Scheinmann, 1978

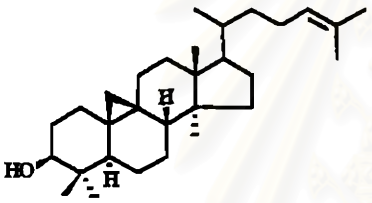


[141]



[142] $R^1 = CH_3$, $R^2 = OH$

[145] $R^1 = H$, $R^2 = H$



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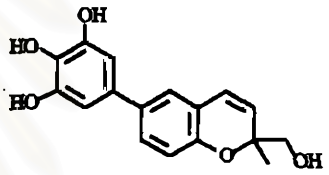
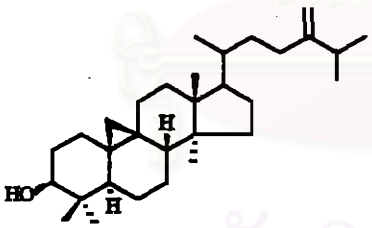
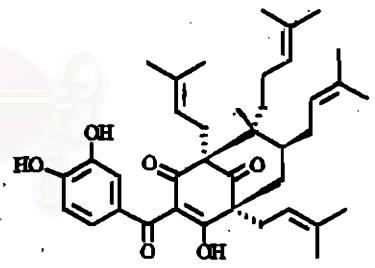


[144]



[146]



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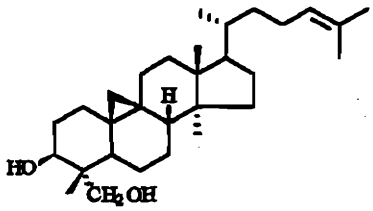

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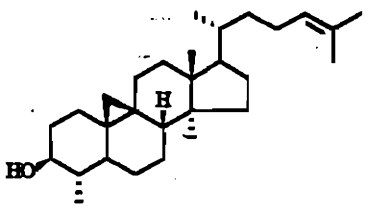
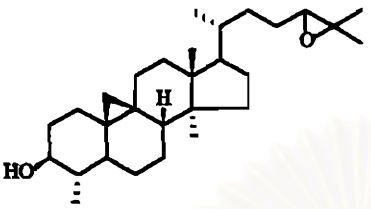


[149]

Table 3 (Continued)

Plant and chemical compound	Category	Plant part	Reference
G. livingstonei			
Guttiferone A [147]	Benzenoid	Fruit	Gustafson *et al.*, 1992
G. lucida			
30-Hydroxycycloartenol [148]	Triterpene	Bark	Nyemba *et al.*, 1990
31-Norcycloartenol [149]	Triterpene	Bark	Nyemba *et al.*, 1990
24R, 25- and 24S, 25-Epoxy-31-norcycloartenol [150]	Triterpene	Bark	Nyemba *et al.*, 1990
G. mangostana			
3-β-Hydroxy-26-nor-9,19-cyclolanost-23-en-25-one [151]	Triterpene	Leaf	Parveen *et al.*, 1991
Egonol [152]	Benzenoid	Fruit hulls	Sakai *et al.*, 1993
Maclurin [153]	Benzenoid	Heartwood	Holloway and Scheinmann, 1975
G. mannii			
3-α-Hydroxy-5-(heptadec-8'-enyl)-tetrahydrofuran-2-one [154]	Lactone	Bark	Hussain and Waterman, 1982
β-Sitosterol [139]	Steroid	Bark	Crichton and Waterman, 1979
Stigmasterol [140]	Steroid	Bark	Crichton and Waterman, 1979
Xanthochymol [155]	Benzenoid	Bark	Crichton and Waterman, 1979
		Leaf	Hussain and Waterman, 1982



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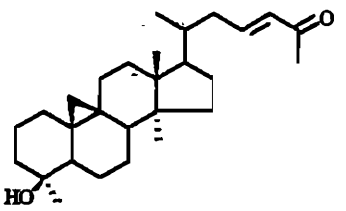
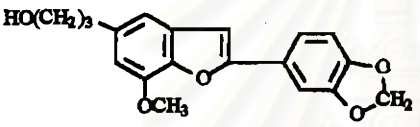
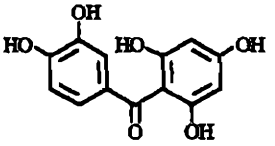


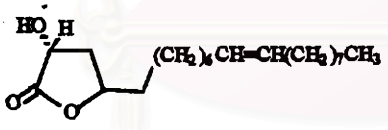
[151]



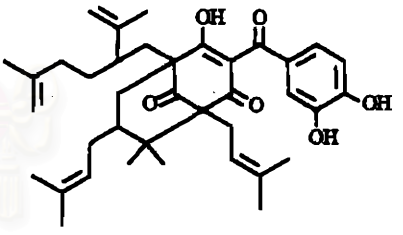
[152]



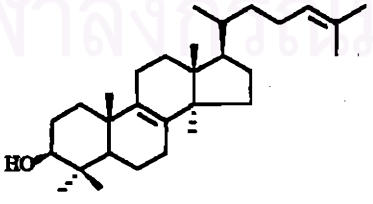
[153]



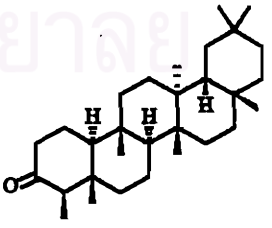
[154]



[155]



[156]



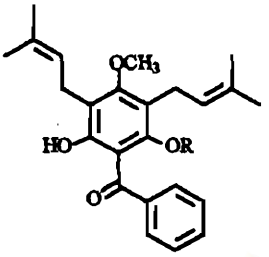
[157]

Table 3 (Continued)

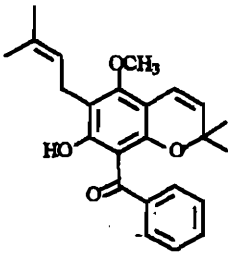
Plant and chemical compound	Category	Plant part	Reference
G. myrtifolia			
Euphol [156]	Triterpene	Bark	Spino *et al.*, 1995
Friedelin [157]	Triterpene	Bark	Spino *et al.*, 1995
Myrtiaphenone A [158]	Benzenoid	Bark	Spino *et al.*, 1995
Myrtiaphenone B [159]	Benzenoid	Bark	Spino *et al.*, 1995
Vismiaphenone C [160]	Benzenoid	Bark	Spino *et al.*, 1995
G. nervosa			
β-Sitosterol [139]	Steroid	Bark	Ampofo and Waterman, 1986
Stigmasterol [140]	Steroid	Bark	Ampofo and Waterman, 1986
G. opaca			
Friedelin [157]	Triterpene	Leaf	Goh *et al.*, 1992
β-Sitosterol [139]	Steroid	Leaf	Goh *et al.*, 1992
Taraxerol [161]	Triterpene	Leaf	Goh *et al.*, 1992
G. ovalifolia			
Friedelin [157]	Triterpene	Bark	Waterman and Crichton, 1980b
Guttiferone E [162]	Benzenoid	Leaf	Gustafson *et al.*, 1992
Isoxanthochymol [163]	Benzenoid	Bark	Waterman and Crichton, 1980b; Goh *et al.*, 1992
		Leaf	Gustafson *et al.*, 1992
β-Sitosterol [139]	Steroid	Bark	Waterman and Crichton, 1980b
Xanthochymol [155]	Benzenoid	Bark	Waterman and Crichton, 1980b

Table 3 (Continued)

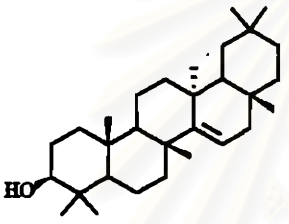
Plant and chemical compound	Category	Plant part	Reference
G. pedunculata			
2,3′,4,5′,6,-Pentahydroxy benzophenone [164]	Benzenoid	Heartwood	Rao *et al.*, 1974
Cambogin [134]	Benzenoid	Pericarp	Sahu, Das and Chatterjee, 1989
Garcinol [135]	Benzenoid	Pericarp	Sahu, Das and Chatterjee, 1989
Pedunculol [165]	Benzenoid	Pericarp	Sahu, Das and Chatterjee, 1989
G. polyantha			
Isoxanthochymol [163]	Benzenoid	Bark	Ampofo and Waterman, 1982
Xanthochymol [155]	Benzenoid	Bark	Ampofo and Waterman, 1982
G. pyrifera			
β-Amyrin [166]	Triterpene	Bark	Ampofo and Waterman, 1986
Oleanolic aldehyde [167]	Triterpene	Bark	Ampofo and Waterman, 1986
G. quaesita			
Hermonionic acid [168]	Benzenoid	Bark	Gunatilaka, Sriyani and Sotheeswaran, 1984
Quaesitol [169]	Benzenoid	Bark	Gunatilaka, Sriyani and Sotheeswaran, 1984



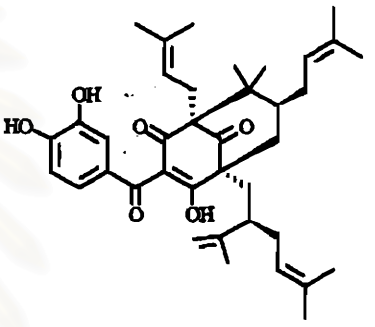
[158] R = CH_3
[160] R = H



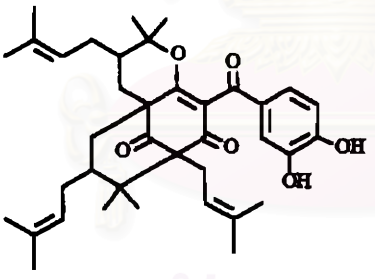
[159]



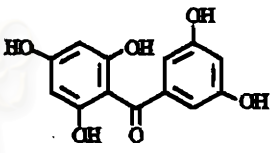
[161]



[162]



[163]



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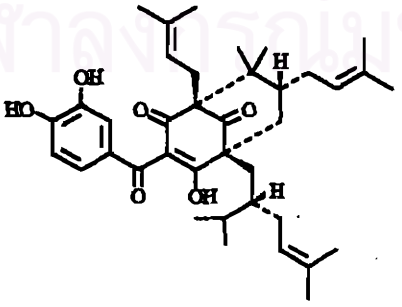
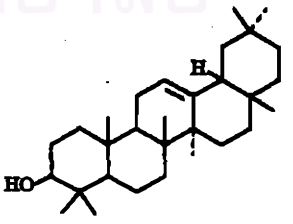


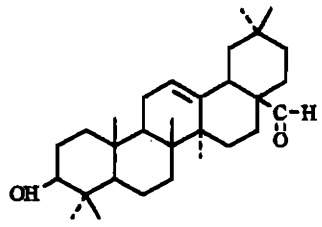
[165]



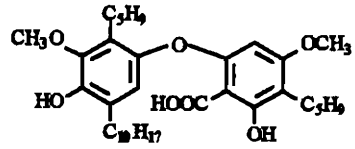
[166]

Table 3 (Continued)

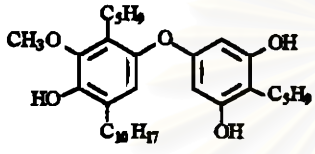
Plant and chemical compound	Category	Plant part	Reference
G. spicata			
Friedelan-3β-ol [170]	Triterpene	Leaf	Gunatilaka *et al.*, 1984
Friedelin [157]	Triterpene	Leaf	Gunatilaka *et al.*, 1984
β-Sitosterol [139]	Steroid	Leaf	Gunatilaka *et al.*, 1984
G. staudtii			
Xanthochymol [155]	Benzenoid	Bark	Waterman and Hussain, 1982
G. subelliptica			
4',6-Dihydroxy-2,3',4-trimethoxybenzophenone [171]	Benzenoid	Heartwood	Minami *et al.*, 1994
Subellinone [172]	Benzenoid	Heartwood	Fukuyama *et al.*, 1993
G. terpnophylla			
β-Sitosterol [139]	Steroid	Heartwood	Bandaranayake *et al.*, 1975
		Bark	Bandaranayake *et al.*, 1975
G. thwaitesii			
β-Amyrin [166]	Triterpene	Bark and timber	Gunatilaka *et al.*, 1983
Tirucallol [173]	Triterpene	Bark and timber	Gunatilaka *et al.*, 1983



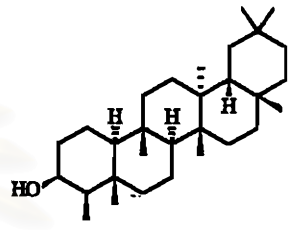
[167]



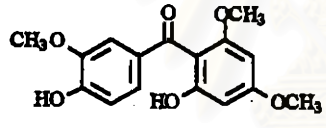
[168]



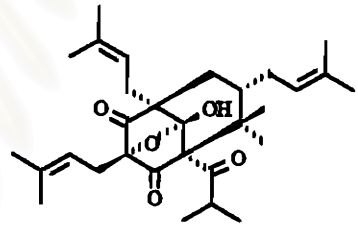
[169]



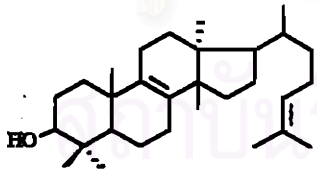
[170]



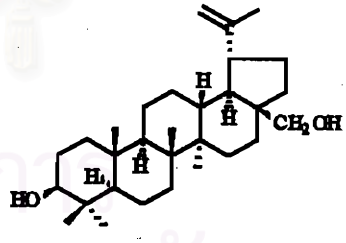
[171]



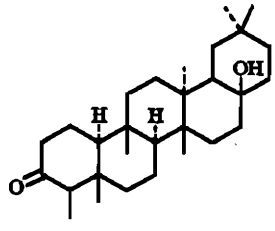
[172]



[173]



[174]



[175]

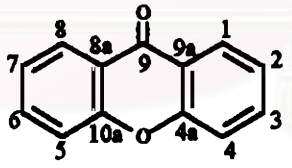
Table 3 (Continued)

Plant and chemical compound	Category	Plant part	Reference
G. xanthochymus			
Betulin [174]	Triterpene	Leaf	Singh *et al.*, 1991
Canophyllol [175]	Triterpene	Leaf	Singh *et al.*, 1991
Friedelin [157]	Triterpene	Leaf	Singh *et al.*, 1991
β-Sitosterol [139]	Steroid	Leaf	Singh *et al.*, 1991

2. Xanthones of the Genus *Garcinia*

2.1 Introduction

The term xanthone (from the Greek ξανθδs, meaning yellow) designates the chemical compound dibenzo-γ-pyrone [176]. The parent substance (which forms almost colorless needles melting at 173-174 °C) does not occur in nature, but a number of its oxygenated derivatives, which are yellow in color, have been isolated from a variety of natural sources. The xanthones bear a close structural relationship to the other naturally occuring γ-pyrone derivatives, the flavonoids and the chromones (Roberts, 1961).



[176]

2.2 Biosynthesis of Naturally Occuring Xanthones

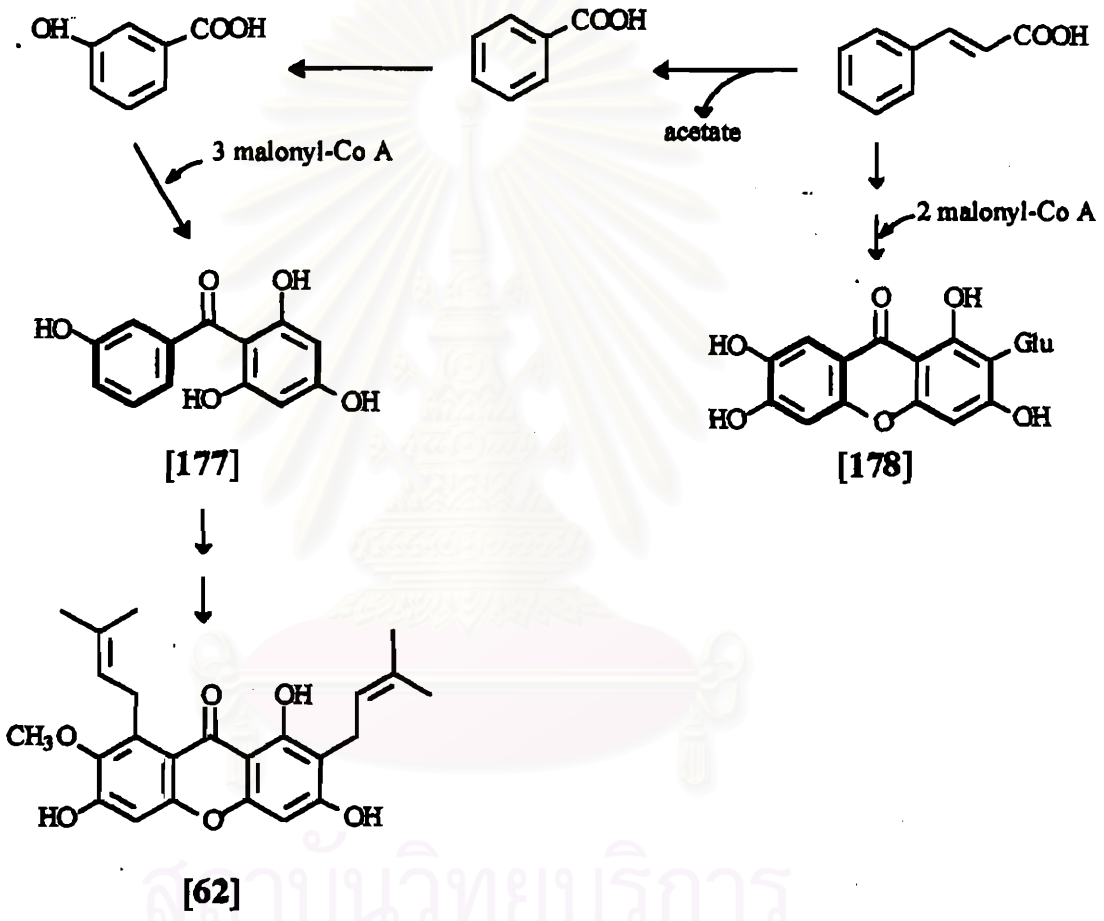
According to Bennett and Lee (1988), the xanthones produced by fungi have been shown to be wholly acetate-derived, whereas those found in higher plants appear to be formed by a mixed shikimate-acetate route. There has been much speculation regarding the nature of the shikimate moiety and the mode of xanthone formation.

Tracer studies have indicated that the 1,3,7-trioxygenated xanthones of *Gentiana lutea* L. (Gentianaceae) are formed from three active acetate (malonate) units and a C_6-C_1 unit derived from phenylalanine (ring B) *via* oxidative coupling of the intermediate benzophenone [177].

In contrast, the *C*-glucosylxanthone, mangiferin [178], has been shown to derive from a C_6-C_3 unit (*p*-coumarate) and two C_2 units, confirming the suspected biogenetic relationship between [178] and flavonoids.

Bennett and Lee (1988) have reported the findings of preliminary study on the biosynthesis of xanthones in the Guttiferae. Cinnamic acid, benzoic acid, *m*-hydroxybenzoic acid and the benzophenone as well as malonic acid were efficient precursors to mangostin [62] in *Garcinia mangostana* implying the pathway depicted in Scheme 1.

Furthermore, the labelled benzophenone [177] was significantly incorporated into 8-desoxygartanin [46] and gartanin in the same plant These findings, coupled with the earlier studies on *Gentiana lutea*, indicate the involvement of benzophenone in the biosynthesis of xanthones with four different oxygenation patterns (1,3,5-, 1,3,7-, 1,3,6,7- and 1,3,5,8-) and suggest that it may be an intermediate in the biosynthesis of most higher plant xanthones (Bennett and Lee, 1989).



Scheme 1 Biosynthesis of xanthones in the Guttiferae

2.3 Classification of Xanthones of the Genus *Garcinia*

According to Bennett and Lee (1989), xanthones of the genus *Garcinia* could be classified into four groups :-

2.3.1 Simple oxygenated xanthones

A number of oxygenated xanthones have been found in the genus *Garcinia*. They can be divided into three groups according to the degree of oxygenation : dioxygenated, trioxygenated and tetraoxygenated xanthones (Bennett and Lee, 1989), as shown in Table 4.

Table 4 Simple oxygenated xanthones of the genus *Garcinia*

Chemical compound	Source	Reference
Dioxygenated xanthones		
1,5-Dihydroxyxanthone [8]	*G. echinocarpa*	Bandaranayake *et al.*, 1975
	G. subelliptica	Minami *et al.*, 1994
	G. terpnophylla	Bandaranayake *et al.*, 1975
1,7-Dihydroxyxanthone (Euxanthone) [10]	*G. eugenifolia*	Jackson, Locksley and Scheinmann,1969
	G. indica	Cotterill, Scheinmann and Puranik, 1977
	G. terpnophylla	Bandaranayake *et al.*, 1975
Trihydroxygenated xanthones		
1,5-Dihydroxy-3-methoxyxanthone [82]	*G. subelliptica*	Iinuma *et al.*, 1995a
1,6-Dihydroxy-5-methoxyxanthone [83]	*G. subelliptica*	Minami *et al.*, 1994
1,7-Dihydroxy-3-methoxyxanthone (Gentisin) [11]	*G. eugenifolia*	Jackson, Locksley and Scheinmann,1969

Table 4 (Continued)

Chemical compound	Source	Reference
1,8-Dihydroxy-6-methoxyxanthone [84]	*G. subelliptica*	Minami *et al.*, 1994
2,5-Dihydroxy-1-methoxyxanthone [85]	*G. subelliptica*	Minami *et al.*, 1996
1,2,5-Trihydroxyxanthone [103]	*G. subelliptica*	Minami *et al.*, 1994
1,5,6- Trihydroxyxanthone [12]	*G. eugenifolia*	Jackson, Locksley and Scheinmann, 1969
1,6,7-Trihydroxyxanthone [13]	*G. eugenifolia*	Jackson, Locksley and Scheinmann, 1969
Subelliptenone G [99]	*G. subelliptica*	Iinuma *et al.*, 1995a, Minami *et al.*, 1995
Tetrahydroxygenated xanthones		
BR-xanthone B [43]	*G. mangostana*	Balasubramanian and Rajagopalan, 1988
1,2-Dihydroxy-5,6-dimethoxyxanthone [80]	*G. subelliptica*	Minami *et al.*, 1994
2,5-Dihydroxy-1,6-dimethoxyxanthone [104]	*G. thwaitesii*	Gunatilaka *et al.*, 1983
2,6-Dihydroxy-1,5-dimethoxyxanthone [81]	*G. subelliptica*	Minami *et al.*, 1994
1,3,5,7-Tetrahydroxyxanthone [74]	*G. pedunculata*	Rao *et al.*, 1974
1,3,6,7-Tetrahydroxyxanthone [9]	*G. echinocarpa* *G. mangostana* *G. multiflora* *G. pedunculata*	Bandaranayake *et al.*, 1975 Holloway and Scheinmann, 1975 Chen, Lin and Hung, 1975a Rao *et al.*, 1974

Table 4 (Continued)

Chemical compound	Source	Reference
1,4,7-Trihydroxy-3-methoxyxanthone [14]	*G. eugeniifolia*	Jackson, Locksley and Scheinmann, 1969

2.3.2 Prenylated xanthones

Prenylated xanthones of the genus *Garcinia* are usually monoprenyl (C_5) or diprenyl (C_{10}) substituted. The C_5 group may be 3-methyl-2-enyl (as in 40), or 1,1-dimethylprop-2-enyl (as in 19), and these are frequently cyclized with *ortho* hydroxyls giving 2,2-dimethylpyrano (or dihydropyrano), 2,2,3-trimethylfurano, or rarely 2-isopropenyldihydrofurano compounds. Occasionally, hydroxylation or hydration of the side chain occurs. C_{10} substituents, in which two prenyl groups are joined together, include geranyl and lavandulyl (Bennett and Lee, 1989).

The oxygenation patterns of prenylated xanthones are less diverse than in the unprenylated compounds. Four patterns predominate: 1,3,5-, 1,3,7-, 1,3,5,6- and 1,3,6,7-. Dioxygenated compounds are rare (Bennett and Lee, 1989).

Table 5 Prenylated xanthones of the genus *Garcinia*

Chemical compound	Source	Reference
2,8-Bis-(γ,γ-dimethylallyl)-1,3,7-trihydroxyxanthone [41]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987
BR-xanthone A [42]	*G. mangostana*	Balasubramanian and Rajagopalan, 1988
Calabaxanthone [44]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987
Cowanin [1]	*G. cowa*	Na Pattahung *et al.*, 1994

Table 5 (Continued)

Chemical compound	Source	Reference
Cowanol [2]	*G. cowa*	Na Pattahung *et al.*, 1994
Cowaxanthone [3]	*G. cowa*	Na Pattahung *et al.*, 1994
Desoxygambogenin [20]	*G. hanburyi*	Asano *et al.*, 1996
Demethylcalabaxanthone [45]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987
8-Deoxygartanin [46]	*G. mangostana*	Govindachari *et al.*, 1971 Sakai *et al.*, 1993
6-Deoxy-γ-mangostin [47]	*G. mangostana*	Sakai *et al.*, 1993
4″,5″-Dihydro-1,5-dihydroxy-6′,6′-dimethylpyrano(2′,3′:6,7,)-2-(3-methylbut-2-enyl)-4″,4″,5″-trimethyl furano(2″,3″:3,4)xanthone [70]	*G. opaca*	Goh *et al.*, 1992
6,11-Dihydroxy-2,2-dimethylpyrano [3,2-C]xanthen-7(2H)-one [34]	*G. livingstonei*	Sordat-Diserens, Rogers *et al.*, 1992
1,6-Dihydroxy-3-methoxy-2-(3-methyl-2-butenyl)xanthone [48]	*G. mangostana*	Parveen and Khan, 1998
5,9-Dihydroxy-8-methoxy-2,2-dimethyl-7-(3-methylbut-2-enyl)-2H,6H-pyrano[3,2-b]xanthen-6-one [49]	*G. mangostana*	Sen *et al.*, 1980
1,5-Dihydroxy-2-(3-methylbut-2-enyl)-3-methoxyxanthone [50]	*G. mangostana*	Sen *et al.*, 1981; Asai *et al.*, 1995

Table 5 (Continued)

Chemical compound	Source	Reference
1,7-Dihydroxy-2-(3-methylbut-2-enyl)-3-methoxyxanthone [51]	*G. mangostana*	Sen *et al.*, 1981; Mahabusarakam, Wiriyachitra and Taylor, 1987; Asai *et al.*, 1995
6,11-Dihydroxy-3-methyl-3-(4-methylpen-3-enyl)-3H,7H-pyrano [2,3-C]xanthen-7-one [35]	*G. livingstonei*	Sordat-Diserens, Rogers *et al.*, 1992
4-(3′,7′-Dimethylocta-2′,6′-dienyl)-1,3,5-trihydroxy-9H-xanthen-9-one [36]	*G. livingstonei*	Sordat-Diserens, Rogers *et al.*, 1992
Forbexanthone [15]	*G. forbesii*	Harrison *et al.*, 1993
Gambogellic acid [21]	*G. hanburyi*	Asano *et al.*, 1996
Gambogenic acid [22]	*G. hanburyi*	Asano *et al.*, 1996
Gambogenin [23]	*G. hanburyi*	Asano *et al.*, 1996
Gambogenin dimethyl acetal [24]	*G. hanburyi*	Asano *et al.*, 1996
Gambogic acid [25]	*G. hanburyi*	Lin *et al.*, 1993; Asano *et al.*, 1996
Gambogin [26]	*G. hanburyi*	Asano *et al.*, 1996
Garcigerrin A [17]	*G. gerrardii*	Sordat-Diserens, Marston *et al.*, 1989
Garcigerrin B [18]	*G. gerrardii*	Sordat-Diserens, Marston *et al.*, 1989
Garciniaxanthone A [86]	*G. subelliptica*	Fukuyama *et al.*, 1991; Minami *et al.*, 1994
Garciniaxanthone B [87]	*G. subelliptica*	Fukuyama *et al.*, 1991; Minami *et al.*, 1994
Garciniaxanthone C [88]	*G. subelliptica*	Minami *et al.*, 1994

Table 5 (Continued)

Chemical compound	Source	Reference
Garciniaxanthone D [89]	*G. subelliptica*	Minami *et al.*, 1995
Garciniaxanthone E [90]	*G. subelliptica*	Minami *et al.*, 1996
Garcinone A [52]	*G. mangostana*	Sen *et al.*, 1982
Garcinone B [53]	*G. mangostana*	Sen *et al.*, 1982; Sakai *et al.*, 1993
Garcinone C [54]	*G. mangostana*	Sen *et al.*, 1982
Garcinone D [55]	*G. mangostana*	Sen *et al.*, 1986
Garcinone E [56]	*G. mangostana*	Sakai *et al.*, 1993; Asai *et al.*, 1995
Gartanin [57]	*G. mangostana*	Govindachari, 1971; Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.*, 1995
Globuxanthone [91]	*G. subelliptica*	Fukuyama *et al.*, 1991; Minami *et al.*, 1994; Iinuma *et al.*, 1995b
Hanburin [27]	*G. hanburyi*	Asano *et al.*, 1996
12b-Hydroxy-des-D-garcigerrin A [19]	*G. gerrardii*	Sordat-Diserens, Marston *et al.*, 1989
	G. livingstonei	Sordat-Diserens, Rogers *et al.*, 1992
	G. subelliptica	Fukuyama *et al.*, 1991; Iinuma *et al.*, 1995b
Isocowanin [76]	*G. pyrifera*	Ampofo and Waterman, 1986

Table 5 (Continued)

Chemical compound	Source	Reference
Isocowanol [77]	*G. pyrifera*	Ampofo and Waterman, 1986
Isogambogenin [28]	*G. hanburyi*	Asano *et al.*, 1996
Isogambogic acid [29]	*G. hanburyi*	Lin *et al.*, 1993; Asano *et al.*, 1996
1-Isomangostin [58]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987
3-Isomangostin [59]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987
1-Isomangostin hydrate [60]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987
3-Isomangostin hydrate [61]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987
Isomorellinol [30]	*G. hanburyi*	Lin *et al.*, 1993; Asano *et al.*, 1996
Isomoreollin B [31]	*G. hanburyi*	Asano *et al.*, 1996
Isorheediaxanthone B [75]	*G. polyantha*	Ampofo and Waterman, 1986
Macluraxanthone [71]	*G. opaca* *G. ovalifolia*	Goh *et al.*, 1992 Waterman and Crichton, 1980b

Table 5 (Continued)

Chemical compound	Source	Reference
α-Mangostin [62]	*G. mangostana*	Sen *et al.*, 1981; Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.*, 1995
β-Mangostin [63]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.*, 1995
γ-Mangostin [64]	*G. mangostana*	Mahabusarakam, Wiriyachitra and Taylor, 1987; Sakai *et al.*, 1993; Asai *et al.*, 1995
Mangostinone [65]	*G. mangostana*	Asai *et al.*, 1995
1-*O*-Methylsymphoxanthone [92]	*G. subelliptica*	Minami *et al.*, 1996
Morellin dimethyl acetal [32]	*G. hanburyi*	Asano *et al.*, 1996
Moreollic acid [33]	*G. hanburyi*	Asano *et al.*, 1996
Nervosaxanthone [68]	*G. nervosa*	Ampofo and Waterman, 1986
Norcowanin [4]	*G. cowa*	Na Pattalung *et al.*, 1994
Pyranojacareubin [7]	*G. densivenia* *G. forbesii*	Waterman and Crichton, 1980a Harrison *et al.*, 1993

Table 5 (Continued)

Chemical compound	Source	Reference
Rheediaxanthone A [79]	*G. staudtii*	Waterman and Hussain, 1982
Rubraxanthone [69]	*G. nervosa* *G. pyrifera*	Ampofo and Waterman, 1986 Ampofo and Waterman, 1986
Subelliptenone A [93]	*G. subelliptica*	Iinuma *et al.*, 1994
Subelliptenone B [94]	*G. subelliptica*	Iinuma *et al.*, 1994
Subelliptenone C [95]	*G. subelliptica*	Iinuma *et al.*, 1995b
Subelliptenone D [96]	*G. subelliptica*	Iinuma *et al.*, 1995b
Subelliptenone E [97]	*G. subelliptica*	Iinuma *et al.*, 1995a
Subelliptenone F [98]	*G. subelliptica*	Iinuma *et al.*, 1995a
Subelliptenone H [100]	*G. subelliptica*	Iinuma *et al.*, 1995c
Subelliptenone I [101]	*G. subelliptica*	Iinuma *et al.*, 1995c
Symphoxanthone [102]	*G. subelliptica*	Minami *et al.*, 1996
1,3,5-Trihydroxy-4,8-di(3,3-dimethyl allyl)xanthone [78]	*G. quadrifaria*	Waterman and Hussain, 1982
1,3,5-Trihydroxy-6′,6′-dimethylpyrano (2′,3′:6,7)-4-(1,1-dimethylprop-2-enyl)xanthone [72]	*G. opaca*	Goh *et al.*, 1992
1,3,5-Trihydroxy-6′,6′-dimethylpyrano (2′,3′:6,7)-2-(3-methylbut-2-enyl)-4-(1,1-dimethylprop-2-enyl)xanthone [73]	*G. opaca*	Goh *et al.*, 1992
1,3,6-Trihydroxy-7-methoxy-2,5-bis(3-methyl-2-butenyl)xanthone [5]	*G. cowa*	Na Pattahmg *et al.*, 1994
1,3,6-Trihydroxy-7-methoxy-8-(3,7-dimethyl-2,6-octadienyl)xanthone [6]	*G. cowa*	Lee and Chan, 1977

Table 5 (Continued)

Chemical compound	Source	Reference
1,5,8-Trihydroxy-3-methoxy-2(3-methyl-2-butenyl)xanthone [67]	*G. mangostana*	Parveen and Khan, 1987; Parveen and Khan, 1988; Sakai *et al.*, 1993
1,3,7-Trihydroxy-2-(3-methylbut-2-enyl)xanthone [16]	*G. forbesii*	Harrison *et al.*, 1993
1,4,5-Trihydroxy-3-(3-methylbut-2-enyl)-9H-xanthen-9-one [40]	*G. livingstonei*	Sordat-Diserens, Rogers *et al.*, 1992

2.3.3 Dimeric xanthones

Only three dimeric xanthones have been found in the genus *Garcinia*. They are xanthone dimers linked *via* a terpene bridge (Bennett and Lee, 1989), as shown in Table 6.

Table 6 Dimeric xanthones of the genus *Garcinia*

Chemical compound	Source	Reference
Garcilivin A [37]	*G. livingstonei*	Sordat-Diserens, Hamburger *et al.*, 1992
Garcilivin B [38]	*G. livingstonei*	Sordat-Diserens, Hamburger *et al.*, 1992
Garcilivin C [39]	*G. livingstonei*	Sordat-Diserens, Hamburger *et al.*, 1992

2.3.4 Xanthone glycosides

There is only one example of *O*-glycosylxanthone in the genus *Garcinia* (Bennett and Lee, 1989), as shown in Table 7.

Table 7 Xanthone glycosides of the genus *Garcinia*

Chemical compound	Source	Reference
1,3,6,7-Tetrahydroxyxanthone-*O*-β-D-glucoside [66]	*G. mangostana*	Holloway and Scheinmann, 1975