# PARATOCARPINS F - L, SEVEN NEW ISOPRENOID-SUBSTITUTED FLAVONOIDS FROM *PARATOCARPUS VENENOSA* ZOLL[1]

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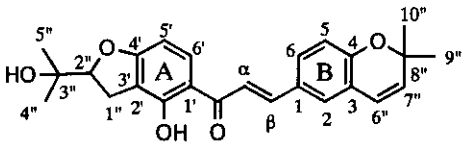
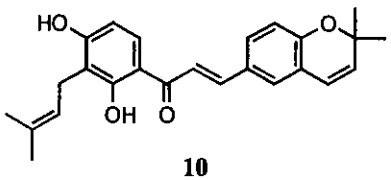
**Abstract** — Two new isoprenoid substituted chalcones, paratocarpins F (**1**) and G (**2**), along with five new isoprenoid substituted flavanones, paratocarpins H (**3**), I (**4**), J (**5**), K (**6**), and L (**7**), were isolated from the Indonesian moraceous plant, *Paratocarpus* (= *Artocarpus*) *venenosa* Zoll. The structures of paratocarpins F, G, H, I, J, K, and L were shown to be **1**, **2**, **3**, **4**, **5**, **6**, and **7**, respectively, on the basis of spectroscopic and chemical evidence.

Previously we reported the structure determination of five isoprenoid-substituted chalcones, paratocarpins A - E, isolated from *Paratocarpus* (= *Artocarpus*) *venenosa* Zoll.[2] Further extension of studies on the components of *P. venenosa* led to the isolation of two new isoprenoid-substituted chalcones, paratocarpins F (**1**) and G (**2**), along with five new isoprenoid-substituted flavanones, paratocarpins H (**3**), I (**4**), J (**5**), K (**6**), and L (**7**). This paper deals with characterization of these new flavonoids as well as the known compounds, gancaonin Q[3] (**8**) and 6-prenylapigenin (**9**).[4]

Paratocarpin F (**1**), yellow prisms, mp 89 - 91 °C, $C_{25}H_{26}O_5$, showed positive reaction to methanolic ferric chloride reaction. The ir spectrum disclosed absorption bands due to hydroxyl, conjugated carbonyl, and benzene ring moieties. The uv spectrum of **1** exhibited maxima at 210, 225 (sh), 289, and 377 nm, and was similar to that of paratocarpin C[2] (**10**), indicating that **1** is a 2', 4, 4'-oxygenated chalcone derivative. The $^1$H nmr spectrum of **1** showed the signals of the following protons (acetone-$d_6$, 400 MHz): protons in a 2,2-dimethylpyran ring, δ 1.45 (6H, s), 5.83, 6.47 (each 1H, d, $J$ = 10 Hz), *ortho*-coupled aromatic protons, δ 6.40, 8.09 (each 1H, d, $J$ = 9 Hz), ABX type aromatic protons, δ 6.81 (1H, d, $J$ = 8 Hz), 7.60 (1H, d, $J$ = 2 Hz), 7.64 (1H, dd, $J$ = 2 and 8 Hz), two olefinic protons, δ 7.81 (2H, s), proton in a hydrogen-bonded hydroxyl group, δ 13.66 (1H, s), protons in a 2-(1-hydroxy-1-methylethyl)-



**1**



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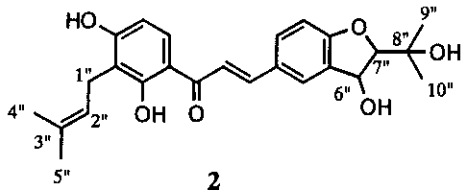
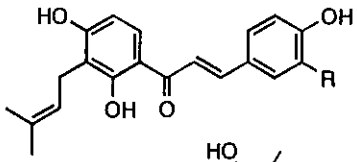


**2**



**11**: R =

**12**: R =

Figure 1

Table 1 $^{13}$C Nmr chemical shifts (ppm) of **1**, **2**, **10**, **11**, and **12** (δ in acetone-$d_6$)

| C | **1** | **2** | **10** | **11** | **12** |
|---|---|---|---|---|---|
| C-1 | 128.8 | 128.8 | 128.8 | 127.6 | 127.7 |
| C-2 | 127.8 | 127.0 | 127.8 | 133.6 | 131.7 |
| C-3 | 122.4 | 132.5 | 122.4 | 127.7 | 129.7 |
| C-4 | 156.5 | 163.7 | 156.4 | 159.9 | 158.7 |
| C-5 | 117.5 | 111.0 | 117.5 | 117.5 | 116.4 |
| C-6 | 131.4 | 132.6 | 131.3 | 130.1 | 129.2 |
| C-α | 119.2 | 118.7 | 119.2 | 118.3 | 118.2 |
| C-β | 144.8 | 145.0 | 144.6 | 145.2 | 145.4 |
| C=O | 193.0 | 193.0 | 193.0 | 193.1 | 193.1 |
| C-1' | 115.5 | 114.5 | 114.5 | 114.5 | 114.4 |
| C-2' | 168.3 | 165.2 | 165.2 | 165.2 | 165.2 |
| C-3' | 114.7 | 116.2 | 116.2 | 116.2 | 116.2 |
| C-4' | 162.5 | 162.8 | 162.8 | 162.7 | 162.7 |
| C-5' | 102.4 | 108.1 | 108.1 | 108.0 | 108.0 |
| C-6' | 133.2 | 130.3 | 130.3 | 130.2 | 130.2 |
| C-1" | 27.5 | 22.3 | 22.3 | 22.3 | 22.3 |
| C-2" | 92.6 | 123.3 | 123.3 | 123.3 | 123.3 |
| C-3" | 71.5 | 131.5 | 131.5 | 131.5 | 131.5 |
| C-4" | 25.5 | 17.9 | 17.9 | 17.9 | 17.9 |
| C-5" | 26.0 | 25.9 | 25.9 | 25.9 | 25.9 |
| C-6" | 122.3 | 72.9 | 122.4 | 38.7 | 29.1 |
| C-7" | 132.5 | 98.9 | 132.4 | 76.7 | 123.3 |
| C-8" | 78.0 | 71.1 | 78.0 | 148.4 | 132.8 |
| C-9" | 28.4 | 25.8 | 28.4 | 110.8 | 17.9 |
| C-10" | 28.4 | 26.4 | 28.4 | 18.3 | 25.9 |

Assignments were performed by 2D $^{13}$C-$^{1}$H shift correlation spectroscopic methods (CHCOSY, COLOC, HMBC).

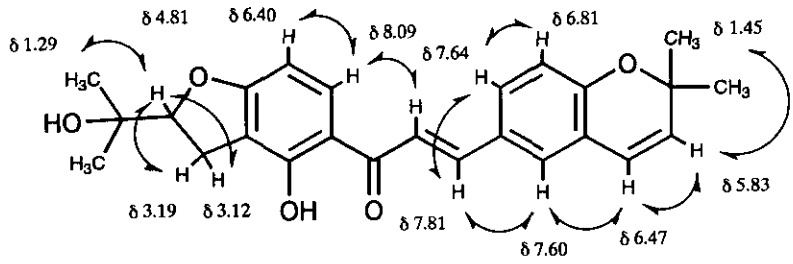



Figure 2 NOESY spectrum of **1**

2,3-dihydrofuran ring,[5] δ 1.24, 1.29 (each 3H, s), 3.12 (1H, dd, $J$ = 10 and 16 Hz), 3.19 (1H, dd, $J$ = 8 and 16 Hz), 4.81 (1H, dd, $J$ = 8 and 10 Hz). The $^{13}$C nmr spectrum of **1** was analysed by comparing with that of **10** (Table 1). In the spectrum, the chemical shifts of all the carbon atoms except those of the carbons of the A ring and isoprenoid moiety on the ring were good agreement with those of the relevant carbons of **10**. This result supports that the 2-(1-hydroxy-1-methylethyl)-2,3-dihydrofuran ring locates on the A ring. Furthermore the location of the 2,2-dimethylpyran ring was confirmed by the two dimetional NOE spectroscopy (NOESY) spectrum of **1** as described in Figure 2. From above results, the structure of paratocarpin F is characterized as **1**.

Paratocarpin G (**2**), yellow needles, mp 113 - 116 °C, $C_{25}H_{28}O_6$, showed positive reaction to methanolic ferric chloride reaction. The uv spectrum of **2** exhibited maxima at 204, 240 (sh), 315 (sh), 369 nm, and was similar to those of paratocarpin D (**11**)[2] and kanzonol C (**12**).[6,7] The $^1$H nmr spectrum of **2** showed the signals of the following protons (acetone-$d_6$, 400 MHz): protons in a 3,3-dimethylallyl group, δ 1.65, 1.78 (each 3H, s), 3.38 (2H, br d, $J$ = 7 Hz), 5.28 (1H, m), *ortho*-coupled aromatic protons, δ 6.54, 8.00 (each 1H, d, $J$ = 9 Hz), ABX type aromatic protons, δ 6.86 (1H, d, $J$ = 8 Hz), 7.71 (1H, dd, $J$ = 2 and 8 Hz), 7.88 (1H, d $J$ = 2 Hz), two olefinic protons, δ 7.79, 7.87 (each 1H, d, $J$ = 15 Hz), proton in a hydrogen-bonded hydroxyl group, δ 13.97 (1H, s), two methyl protons, δ 1.27, 1.29 (each 3H, s), two methine protons, δ 4.36 (1H, d, $J$ = 4 Hz), 5.45 (1H, dd, $J$ = 4 and 7 Hz), proton in a hydroxyl group, δ 4.84 (1H, d, $J$ = 7 Hz). The $^{13}$C nmr spectrum of **2** was analysed by comparing with those of **11** and **12** as described in Table 1. In the spectrum of **2**, the chemical shifts of all the carbon atoms except those of the carbons of the B ring and the isoprenoid moiety on the ring were good agreement with those of the relevant carbons of **12**. The presence of 2-(1-hydroxy-1-methylethyl)-3-hydroxy-2,3-dihydrofuran ring in the structure along with the locations of the ring and the 3,3-dimethylallyl group was confirmed by the HMBC spectrum as described in Figure 3. The relative configuration between 6"-H and 7"-H was

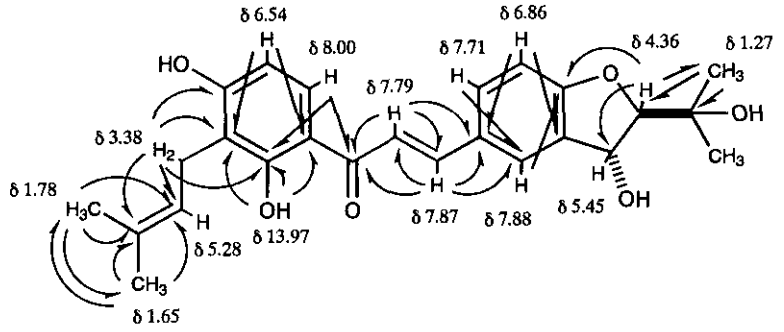



Figure 3 HMBC spectrum of **2** ($J_{CCH}$ = 6 Hz)

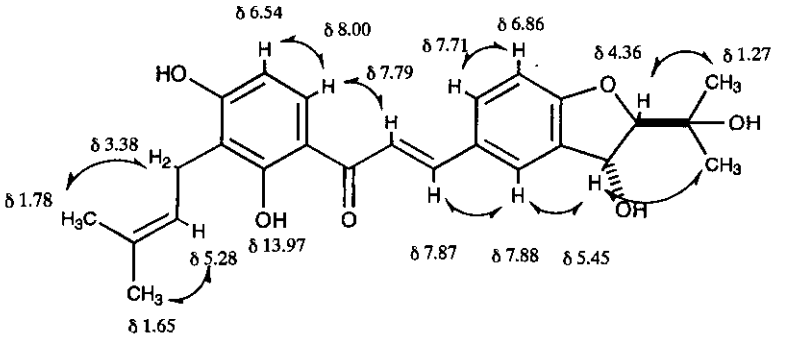
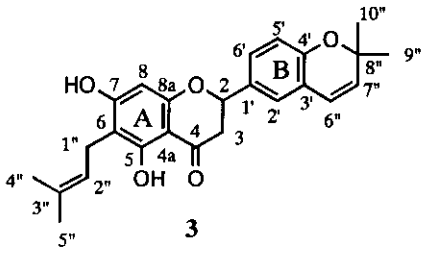



Figure 4 NOESY spectrum of **2**

supported by consideration of the NOESY spectrum of **2** (Figure 4). In the spectrum, the NOE was observed between the 6"-H and the 9"-H as well as the 10"-H. This result supports the relative configuration between 6"-H and 7"-H to be *trans*. From the above results, the structure of paratocarpin G was represented by the formula (**2**).

Paratocarpin H (**3**), colorless prisms, mp 211 - 212 °C, $C_{25}H_{26}O_5$, showed positive reaction to methanolic ferric chloride reaction, magnesium-hydrochloric acid test, and sodium borohydride test.[8] The uv spectrum exhibited maxima at 225, 294, 340 (sh) nm, and was similar to that of naringenin (**13**).[9] The $^1$H nmr spectrum of **3** showed the signals of the following protons (acetone-*d*6, 400 MHz): protons in a 3,3-dimethylallyl group, δ 1.64, 1.75 (each 3H, s), 3.25 (2H, br d, *J* = 7 Hz), 5.24 (1H, m), protons in a 2,2-dimethylpyran ring, δ 1.42 (6H, s), 5.77, 6.44 (each 1H, d, *J* = 10 Hz), ABX type protons, δ 2.73 (1H, dd, *J* = 3 and 17 Hz), 3.16 (1H, dd, *J* = 13 and 17 Hz), 5.41 (1H, dd, *J* = 3 and 13 Hz), an aromatic proton, δ 6.04 (1H, s), ABX type aromatic protons, δ 6.78 (1H, d, *J* = 8 Hz), 7.23 (1H, d, *J* = 2 Hz), 7.29 (1H, dd, *J* = 2 and 8 Hz), proton in a hydrogen-bonded hydroxyl group, δ 12.46 (1H, s). The $^{13}$C

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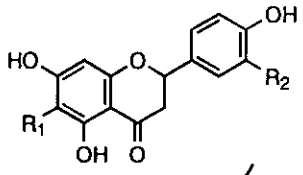
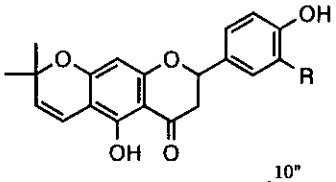
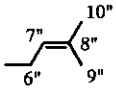



**7**: $R_1 = R_2 =$ 

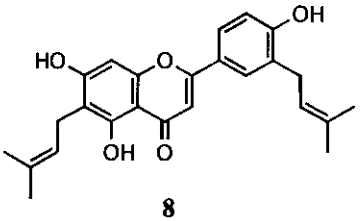
**9**: $R_1 =$  $R_2 = H$

**13**: $R_1 = R_2 = H$




**4**: R = 


**6**: R = H

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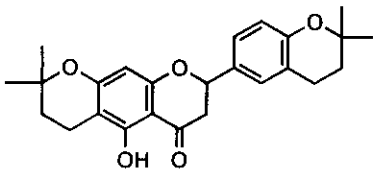


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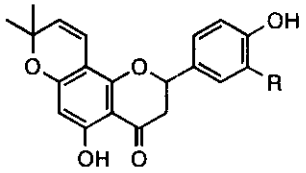
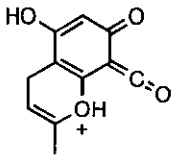



**14**: R = 

**19**: R = H

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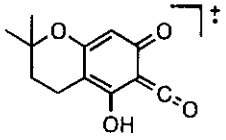


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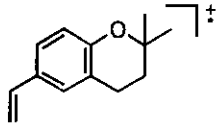


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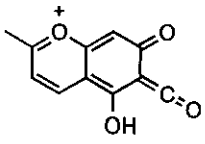


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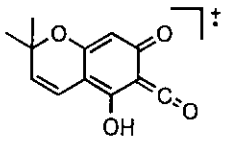


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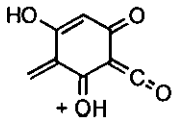


**21**

Figure 5

Table 2 $^{13}C$ Nmr chemical shifts (ppm) of **3**, **4**, **5**, **6**, and **7**

| C | 3[a] | 4[b] | 5[a] | 6[b] | 7[a] |
|---|---|---|---|---|---|
| C-2 | 79.7 | 79.1 | 79.9 | 78.9 | 80.1 |
| C-3 | 43.6 | 43.2 | 43.7 | 43.2 | 43.7 |
| C-4 | 197.2 | 196.1 | 197.6 | 196.0 | 197.4 |
| C-4a | 103.3 | 102.9 | 103.0 | 102.9 | 103.2 |
| C-5 | 162.3 | 162.5 | 162.2 | 162.4 | 162.3 |
| C-6 | 109.1 | 103.0 | 102.6 | 103.1 | 109.4 |
| C-7 | 164.8 | 158.4 | 161.7 | 158.5 | 164.8 |
| C-8 | 95.3 | 96.3 | 96.6 | 96.3 | 95.4 |
| C-8a | 162.0 | 162.1 | 163.6 | 162.2 | 162.1 |
| C-1' | 132.4 | 130.5 | 131.0 | 130.7 | 131.0 |
| C-2' | 125.7 | 128.2 | 129.0 | 128.0 | 129.1 |
| C-3' | 122.2 | 127.3 | 121.9 | 115.7 | 129.0 |
| C-4' | 154.2 | 154.9 | 155.4 | 156.1 | 156.2 |
| C-5' | 117.0 | 116.0 | 118.0 | 115.7 | 115.8 |
| C-6' | 128.4 | 125.7 | 126.6 | 128.0 | 126.2 |
| C-1" | 21.6 | 115.3 | 16.3 | 115.3 | 21.7 |
| C-2" | 123.6 | 126.2 | 32.4 | 126.3 | 123.5 |
| C-3" | 131.3 | 78.3 | 75.1 | 78.3 | 131.2 |
| C-4" | 25.9 | 28.4 | 26.8 | 28.4 | 25.9 |
| C-5" | 17.8 | 28.4 | 27.0 | 28.4 | 17.9 |
| C-6" | 122.7 | 29.9 | 23.1 | | 29.1 |
| C-7" | 132.2 | 121.2 | 33.3 | | 123.6 |
| C-8" | 77.2 | 135.4 | 77.0 | | 132.7 |
| C-9" | 28.2 | 25.8 | 27.1 | | 25.9 |
| C-10" | 28.2 | 17.9 | 27.1 | | 17.9 |

Assignments were performed by 2D shift correlation spectroscopic methods (CHCOSY, COLOC, HMBC)

Solvent: a; acetone-*d6* b; $CDCl_3$

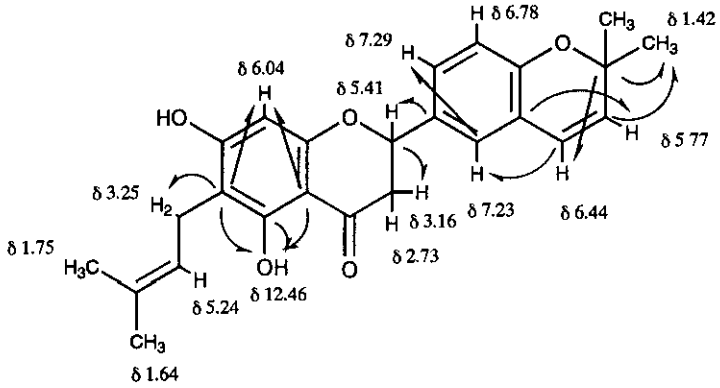


Figure 6 COLOC spectrum of **3** ($J_{CCH}$ = 6 Hz)

nmr spectrum of **3** was analysed by comparing with those of flavanone derivatives[10] (Table 2). From above results, compound **3** is a 5,7,4'-oxygenated flavanone derivative. The location of the 3,3-dimethylallyl group and the 2,2-dimethylpyran ring was confirmed by the COLOC spectrum (Figure 6). From the above results, the structure of paratocarpin H is characterized as **3**.

Paratocarpin I (**4**), pale yellow oily substance, $C_{25}H_{26}O_5$, showed positive reaction to methanolic ferric chloride reacion, magnesium-hydrochloric acid test, and sodium borohydride test. The uv spectrum exhibited maxima at 203, 226, 272, 294, 305 (sh), 360 nm, and was similar to euchrenone $a_2$ (**14**).[11] The $^1$H nmr spectrum of **4** showed the signals of the following protons (acetone-*d*6, 400 MHz): protons in a 3,3-dimethylallyl group, δ 1.78 (6H, s), 3.38 (2H, br d, *J* = 7 Hz), 5.32 (1H, m), protons in a 2,2-dimethylpyran ring, δ 1.43, 1.44 (each 3H, s), 5.50, 6.62 (each 1H, d, *J* = 10 Hz), ABX type protons, δ 2.76 (1H, dd, *J* = 3 and 17 Hz), 3.08 (1H, dd, *J* = 13 and 17 Hz), 5.31 (1H, dd, *J* = 3 and 13 Hz), an aromatic proton, δ 5.95 (1H, s), ABX type aromatic protons, δ 6.84 (1H, d, *J* = 8 Hz), 7.18 (1H, d, *J* = 2 Hz), 7.19 (1H, dd, *J* = 2 and 8 Hz), proton in a hydrogen-bonded hydroxyl group, δ 12.31 (1H, s). Comparative examination of the EI-mass spectra of **3** and **4** was carried out. The EI-mass spectrum of **3** showed the fragment ion at *m/z* 205 (**15**), while that of **4** showed at *m/z* 203 (**16**). This result supports the 2,2-dimethylpyran ring to be on the A ring. The $^{13}$C nmr spectrum of **4** was analysed (Table 2). Fukai, *et al* reported that the chemical shift of the C-1 atom of the 3,3-dimethylallyl group was depend on the substituents located at the adjacent positions.[12] The signal of the C-1 atom of the 3,3-dimethylallyl group

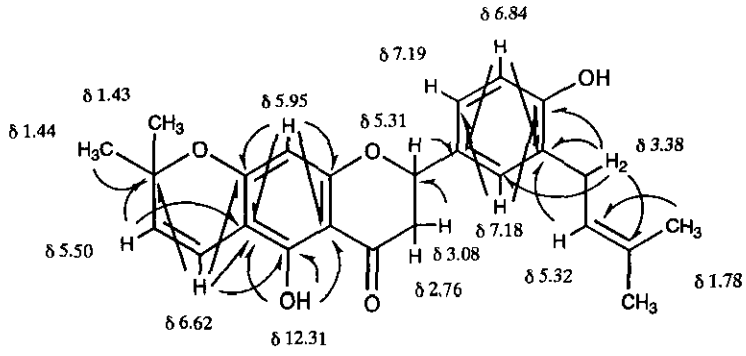


Figure 7 HMBC spectrum of **4** ($J_{CCH}$ = 6 Hz)

of **4** was observed at δ 29.9. This result suggests that one of the *ortho*-positions to the 3,3-dimethylallyl group is replaced by the oxygenated substituent, and the group locates at the C-3' position. The location of the 2,2-dimethylpyran ring was confirmed by the HMBC spectrum of **4** (Figure 7). Thus, the structure of paratocarpin I is characterized as **4**.

Paratocarpin J (**5**), colorless oily substance, $C_{25}H_{28}O_5$, showed positive reaction to methanolic ferric chloride reaction, magnesium-hydrochloric acid test, and sodium borohydride test. The uv spectrum exhibited maxima at 204, 213 (sh), 228 (sh), 294, 330 (sh) nm, and was similar to that of **13**. The $^1$H nmr spectrum of **5** showed the signals of the following protons (acetone-*d*6, 400 MHz): protons in two sets of 2,2-dimethyldihydropyran ring, δ 1.32 (12H, s), 1.83, 1.84, 2.58, 2.85 (each 2H, t, $J$ = 7 Hz), ABX type protons, δ 2.75 (1H, dd, $J$ = 3 and 17 Hz), 3.18 (1H, dd, $J$ = 13 and 17 Hz), 5.40 (1H, dd, $J$ = 3 and 13 Hz), an aromatic proton, δ 5.85 (1H, s), ABX type aromatic protons, δ 6.76 (1H, d, $J$ = 8 Hz), 7.23 - 7.25 (2H, m), a proton in a hydrogen-bonded hydroxyl group, δ 12.56 (1H, s). The EI-mass spectrum of **5** showed the fragment ion at *m/z* 220 (**17**) and 188 (**18**). The location of the 2,2-dimethyldihydropyran ring in the A ring was confirmed by the HMBC spectrum (Figure 8). Thus, the structure of

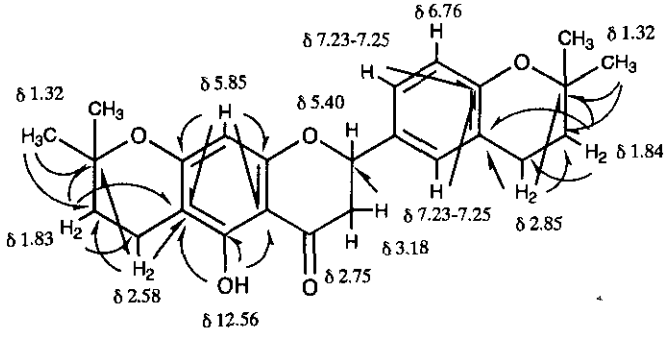


Figure 8 HMBC spectrum of **5** ($J_{CCH}$ = 6 Hz)

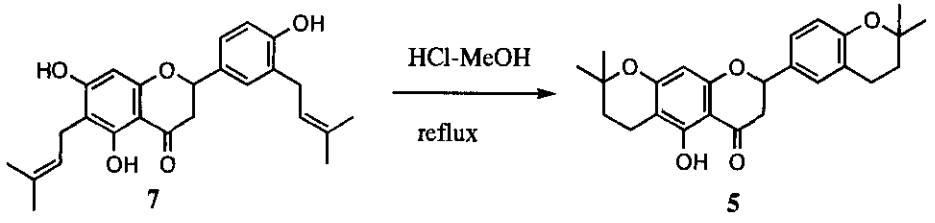


Figure 9 Chemical correlation of compound (**7**) to compound (**5**)

paratocarpin J is characterized as **5**. The structure (**5**) was confirmed by the derivation from paratocarpin L (**7**) (Figure 9). This compound (**5**) has been synthesized by Mitscher *et al.*[13] To our knowledge, this is the first time that it has been identified as a natural product.

Paratocarpin K (**6**), pale yellow prisms, mp 165 - 166 °C, $C_{20}H_{18}O_5$, showed positive reaction to methanolic ferric chloride, magnesium-hydrochloric acid test, and sodium borohydride test. The uv spectrum exhibited maxima at 227, 272, 295, 307, 360 nm, and was similar to those of **4** and citflavanone (**19**).[14] The $^1$H nmr spectrum of **6** showed the signals of the following protons ($CDCl_3$, 400 MHz): protons in a 2,2-dimethylpyran ring, δ 1.43, 1.44 (each 3H, s), 5.50, 6.62 (each 1H, d, $J$ = 10 Hz), ABX type protons, δ 2.78 (1H, dd, $J$ = 3 and 17 Hz), 3.07 (1H, dd, $J$ = 13 and 17 Hz), 5.34 (1H, dd, $J$ = 3 and 13 Hz), $A_2B_2$ type aromatic protons, δ 6.88, 7.32 (each 2H, d, $J$ = 8 Hz), an aromatic proton, δ 5.95 (1H, s), a proton in a hydrogen-bonded hydroxyl group, δ 12.29 (1H, s).. The EI-mass spectrum of **6** showed the fragment ion $m/z$ 218 (**20**). The $^{13}$C nmr spectrum of **6** was analysed by comparing with that of **4** (Table 2). In the spectrum, the chemical shifts of all the carbon atoms except those of the B ring carbons were similar to those of the relevant carbons of **4**. From the above results, the structure of paratocarpin K is characterized as **6**. While the compound (**6**) has been synthesized by Jain *et al*,[15] this is the first time that it has been identified as a natural product.

Paratocarpin L (**7**), colorless needles, mp 169 - 170 °C, $C_{25}H_{28}O_5$, gave a dark blue color with methanolic ferric chloride. The uv spectrum of **7** exhibited maxima at 207, 228 (sh), 292, 334 (sh) nm, indicating that **7** is a flavanone derivative.[9] The $^1$H nmr of **7** showed the signals of the following protons (acetone-*d6*, 400 MHz): protons in two sets of 3,3-dimethylallyl groups, δ 1.64 (3H, s), 1.71 (6H, s), 1.75 (3H, s), 3.25, 3.35 (each 2H, br d, $J$ = 7 Hz), 5.23, 5.35 (each 1H, m), ABX type protons, δ 2.70 (1H, dd, $J$ = 3 and 17 Hz), 3.15 (1H, dd, $J$ = 13 and 17 Hz), 5.39 (1H, dd, $J$ = 3 and 13 Hz), an aromatic proton, δ 6.02 (1H, s), ABX type aromatic protons, δ 6.88 (1H, d, $J$ = 8 Hz), 7.20 (1H, dd, $J$ = 2 and 8 Hz), 7.28 (1H, d, $J$ = 2 Hz), a proton in a hydrogen-bonded hydroxyl group, δ 12.47 (1H, s). The $^{13}$C nmr spectrum of **7** was analysed by comparing with those of flavanones, indicating that **7** is a 5,7,4'-trioxygenated flavanone derivative (Table 2). The EI-mass spectrum of **7** showed the fragment ion at $m/z$ 220 and 165 (**21**). These results suggest that the structure of paratocarpin L is characterized as **7** or **7a**. Paratocarpin L was identified with **7** which was derived from 2-hydroxy-4,6-dimethoxymethoxy-5-prenylacetophenone (**22**)[16] and 4-methoxymethoxy-3-prenylbenzaldehyde (**23**)[17] (Figure 10). Thus, the structure of paratocarpin L was represented by formula (**7**).

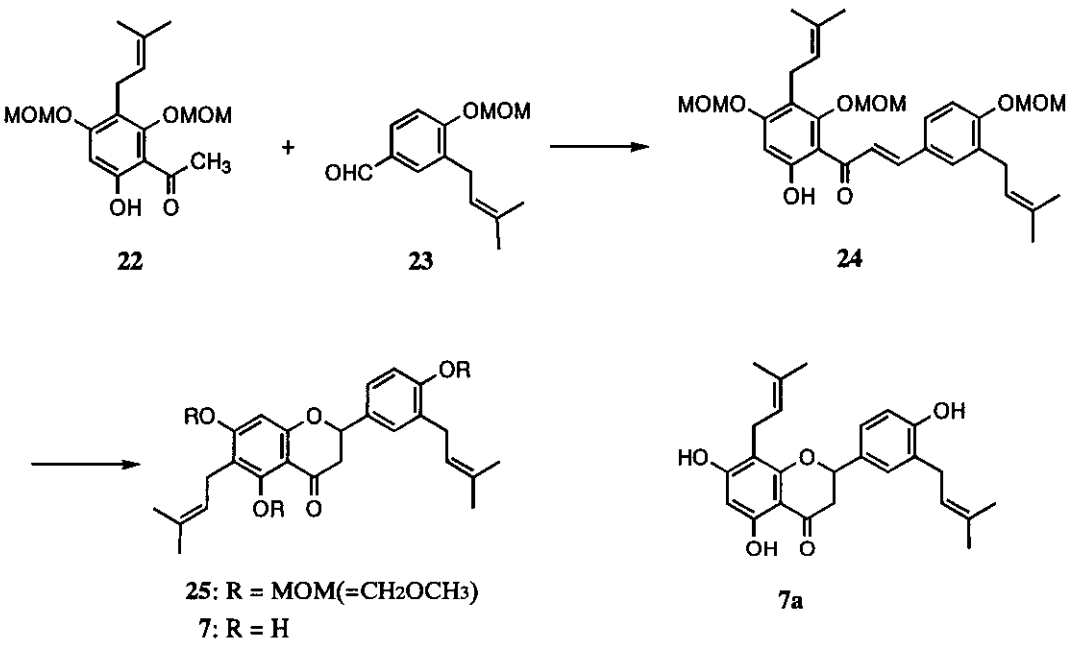


Figure 10 Synthesis of compound (7)

## EXPERIMENTAL

Abbreviations: s = singlet, d = doublet, dd = double doublet, m = multiplet, br = broad, sh = shoulder. The general procedures followed and the instruments used in our previous paper.[2]

*Isolation of Paratocarpins F (1), G (2), H (3), I (4), J (5), K (6), and L (7)*

The dried bark of *P. venenosa* (3.4 kg) was extracted at room temperature with *n*-hexane (9 l, three times), benzene (9 l x 3), and acetone (9 l x 3), successively (each 3 days). Evaporation of the *n*-hexane, benzene and acetone solutions to dryness yielded 60 g, 55 g, and 95 g of the residues, respectively.[2]

The *n*-hexane extract (30 g) was chromatographed over silica gel (300 g) using *n*-hexane, *n*-hexane - ethyl acetate (97 : 3, 95 : 5, 4 : 1), and then ethyl acetate to prepare frs. 1 - 46.[2] The fraction eluted with *n*-hexane - ethyl acetate (95 : 5, frs. 25 and 26, 18 mg) was fractionated by preparative tlc (benzene) to give paratocarpin J (**5**, 2 mg). The fraction eluted with ethyl acetate (frs. 41 - 46, 5 g) was rechromatographed over silica gel (150 g) with *n*-hexane containing increasing amount of ethyl acetate as an eluent (frs. 1' - 58'). The fraction eluted with *n*-hexane - ethyl acetate (4 : 1, frs. 20' - 24', 540 mg) was fractionated by preparative tlc [*n*-hexane - acetone (2 : 1)] to give paratocarpin L (**7**, 36 mg).

The benzene extract (25 g) was chromatographed over silica gel (300 g) using *n*-hexane, *n*-hexane - ethyl acetate (99 : 1, 98 : 2, 96 : 4, 95 : 5, 9 : 1, and 85 : 15) to prepare frs. 1" - 98".[2] The fraction eluted with *n*-hexane - ethyl acetate (98 : 2, frs. 19" and 20", 70 mg) was fractionated by preparative tlc (benzene) to give paratocarpin J (**5**, 2 mg). The fraction eluted with *n*-hexane - ethyl acetate (95 : 5, fr. 37", 150 mg) was fractionated by preparative tlc [*n*-hexane - ethyl acetate (5 : 1)] to give paratocarpin H (**3**, 10 mg). The fraction eluted with *n*-hexane - ethyl acetate (95 : 5, frs. 39" - 43", 200 mg) was fractionated by preparative tlc [*n*-hexane - ethyl acetate (5 : 1)] to give paratocarpin I (**4**, 6 mg). The fraction eluted with *n*-hexane - ethyl acetate (9 : 1, frs. 60" - 65", 210 mg) was fractionated by preparative tlc [*n*-hexane - acetone (2 : 1)] to give paratocarpin F (**1**,

6 mg). The fraction eluted with *n*-hexane - ethyl acetate (9 : 1, frs. 66" - 69", 200 mg) was fractionated by preparative tlc [*n*-hexane - ethyl acetate (3 : 1)] to give paratocarpin K (**6**, 7 mg). The fraction eluted with *n*-hexane - ethyl acetate (85 : 5, frs. 74" and 75", 800 mg) was fractionated by preparative tlc [*n*-hexane - ethyl acetate (2 : 1)] to give paratocarpin L (**7**, 210 mg). The acetone extract (30 g) was chromatographed over silica gel (300 g) using benzene, benzene - acetone (95 : 5, 92 : 8, and 8 : 2) to prepare frs. 1"' - 55"'. The fraction eluted with benzene (fr. 6"', 210 mg) was fractionated by preparative tlc [*n*-hexane - acetone (3 : 1)] to give paratocarpins H (**3**, 5 mg) and I (**4**, 3 mg). The fraction eluted with benzene - acetone (95 : 5, fr. 12"', 95 mg) was fractionated by preparative tlc [*n*-hexane - acetone (2 : 1)] to give gancaonin Q[3] (**8**, 9 mg). The fraction eluted with benzene - acetone (92 : 8, fr. 17"', 164 mg) was fractionated by preparative tlc [$CHCl_3$ - MeOH (50 : 1)] to give 6-prenylapigenin (**9**, 14 mg). The fraction eluted with benzene - acetone (8 : 2, fr. 31"', 120 mg) was fractionated by preparative tlc [$CHCl_3$ - MeOH (10 : 1)] to give paratocarpin G (**2**, 26 mg). The known compound, gancaonin Q[3] (**8**), was identified by direct comparison with the authentic sample. 6-Prenylapigenin (**9**) was identified by comparison with the published data[4] and the authentic sample (**9a**) which was derived from naringenin[18] (**13**).

*Paratocarpin F (1)*

Compound (**1**) was recrystallized from MeOH - $H_2O$ (2 : 1) to give yellow prisms, mp 89 - 91 °C. $FeCl_3$ test: positive (dark brown). $[\alpha]_D^{22}$-6.9° (*c* = 0.1, MeOH). Uv $\lambda_{max}^{MeOH}$ nm (log ε): 210 (4.53), 225 (sh 4.42), 289 (4.20), 377 (4.59). EI- ms: *m/z* (rel. int.) 406 ($M^+$, 24), 391 (100), 373 (3), 347 (4), 338 (8), 203 (6), 187 (6), 171 (31). HR-ms: *m/z* 406.1759 ($M^+$, $C_{25}H_{26}O_5$ requires 406.1780), 391.1516 ($C_{24}H_{23}O_5$ requires 391.1546). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 3430, 2975, 2930, 1640, 1600, 1560, 1490, 1430.

*Paratocarpin G (2)*

Compound (**2**) was recrystallized from MeOH to give yellow needles, mp 113 - 116 °C. $FeCl_3$ test: positive (dark brown). $[\alpha]_D^{22}$0° (*c* = 0.1, MeOH). Uv $\lambda_{max}^{MeOH}$ nm (log ε): 204 (4.66), 240 (sh 4.23), 315 (sh 4.23), 369 (4.62). EI- ms: *m/z* (rel. int.) 424 ($M^+$, 37), 407 (2), 406 (2), 381 (11), 369 (4), 348 (19), 333 (7), 305 (67), 293 (23), 204 (23), 203 (23), 189 (18), 187 (28), 161 (42), 149 (100). HR-ms: *m/z* 424.1855 ($M^+$, $C_{25}H_{28}O_6$ requires 424.1886), 305.0796 ($C_{19}H_{13}O_4$ requires 305.0814). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 3430, 2930, 1630, 1610, 1560, 1490, 1440.

*Paratocarpin H (3)*

Compound (**3**) was recrystallized from *n*-hexane - $CHCl_3$ (1 : 1) to give colorless prisms, mp 211 - 212 °C. $FeCl_3$ test: positive (dark brown). Mg - HCl test: positive (violet). $NaBH_4$ test: positive (orange). $[\alpha]_D^{22}$ -26.1° (*c* = 0.1, MeOH). Uv $\lambda_{max}^{MeOH}$ nm (log ε): 225 (4.57), 294 (4.14), 340 (sh 3.39). EI- ms: *m/z* (rel. int.) 406 ($M^+$, 37), 391 (93), 363 (6), 351 (9), 205 (20), 171 (100). HR-ms: *m/z* 406.1781 ($M^+$, $C_{25}H_{26}O_5$ requires 406.1780), 391.1516 ($C_{24}H_{23}O_5$ requires 391.1546). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 3400 (br), 3140, 2970, 2920, 1650, 1630, 1590, 1490, 1450.

*Paratocarpin I (4)*

Compound (**4**) was obtained as oily substance. $FeCl_3$ test: positive (dark brown). Mg - HCl test: positive (violet). $NaBH_4$ test: positive (orange). $[\alpha]_D^{22}$0° (*c* = 0.1, MeOH). Uv $\lambda_{max}^{MeOH}$ nm (log ε): 203 (4.63), 226 (4.26), 272 (4.48), 294 (4.00), 305 (sh 3.89), 360 (3.50). EI- ms: *m/z* (rel. int.) 406 ($M^+$, 22), 391 (79), 375 (34), 293 (3), 203 (100), 187 (67). HR-ms: *m/z* 406.1771 ($M^+$, $C_{25}H_{26}O_5$ requires 406.1780), 391.1542 ($C_{24}H_{23}O_5$ requires 391.1546). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 3430 (br), 2930, 1650, 1570, 1500, 1450.

*Paratocarpin J (5)*

Compound (**5**) was obtained as oily substance. $FeCl_3$ test: positive (dark brown). Mg - HCl test: positive (violet). $NaBH_4$ test: positive (orange). $[\alpha]_D^{22}$0° ($c$ = 0.1, MeOH). Uv $\lambda_{max}^{MeOH}$ nm (log ε): 204 (4.55), 213 (sh 4.31), 228 (sh 4.25), 294 (4.13), 330 (sh 3.21). EI- ms: *m/z* (rel. int.) 408 ($M^+$, 37), 353 (3), 220 (12), 205 (6), 188 (62), 175 (100), 165 (37), 149 (9). HR-ms: *m/z* 408.1949 ($M^+$, $C_{25}H_{28}O_5$ requires 408.1937). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 3440 (br), 1640, 1580, 1500, 1480, 1440.

*Formation of 5 from 7*

A mixture of **7** (50 mg) and 35% HCl (3 ml) - MeOH (15 ml) solution was refluxed for 2 h, and treated as usual. The product was purified by preparative tlc (benzene) to give **5** (15.5 mg). The compound (**5**) was identified with **5** by comparing the phisical data of **5** with those of **5**.

*Paratocarpin K (6)*

Compound (**6**) was recrystallized from *n*-hexane - $CHCl_3$ (1 : 1) to give yellow proisms, mp 165 - 166 °C. $FeCl_3$ test: positive (dark brown). Mg - HCl test: positive (violet). $NaBH_4$ test: positive (orange). $[\alpha]_D^{22}$0° ($c$ = 0.1, MeOH). Uv $\lambda_{max}^{MeOH}$ nm (log ε): 227 (4.15), 272 (4.51), 295 (3.97), 307 (3.87), 360 (3.33). EI- ms: *m/z* (rel. int.) 338 ($M^+$, 13), 323 (49), 218 (3), 203 (100), 147 (3), 135 (2), 120 (5) HR-ms: *m/z* 338.1131 ($M^+$, $C_{20}H_{18}O_5$ requires 338.1155), 203.0354 ($C_{11}H_7O_4$ requires 203.0344). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 3430 (br), 2930, 1650, 1570, 1520, 1450.

*Paratocarpin L (7)*

Compound (**7**) was recrystallized from *n*-hexane - ethyl ether (1 : 1) to give pale yellow needles, mp 169 - 170 °C. $FeCl_3$ test: positive (dark brown). Mg - HCl test: positive (violet). $NaBH_4$ test: positive (orange). $[\alpha]_D^{22}$ -11° ($c$ = 0.04, EtOH). Uv $\lambda_{max}^{MeOH}$ nm (log ε): *205 (4.35), 210 (4.31), 228 (4.14), 295 (3.99), 336 (3.27).* EI- *ms: m/z (rel. int.)* 408 ($M^+$, 100), 393 (3), 365 (18), 353 (27), 220 (25), 205 (45), 192 (25), 175 (19), 165 (56). HR-ms: *m/z* 408.1936 ($M^+$, $C_{25}H_{28}O_5$ requires 408.1929), 165.0175 ($C_8H_5O_4$ requires 165.0186). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 3450, 3150, 1640, 1600, 1500.

*Formation of 24 from 2-hydroxy-4,6-dimethoxymethoxy-5-prenylacetophenone (22) and 4-methoxymethoxy-3-prenylbenzaldehyde*

A mixture of **22**[16] (110 mg) and **23**[17] (95 mg) in EtOH solution (3 ml) and 25% KOH aqueous solution (1 ml) was kept at room temperature for 15h, and treated as usual. The product was purified by preparative tlc [*n*-hexane - acetone (5 : 1)] to give **24** (21 mg). Compound (**24**) was obtained as yellow oily substance. HR-ms: *m/z* 540.2687 ($M^+$, $C_{31}H_{40}O_8$ requires 540.2712). $^1H$ Nmr (acetone-$d_6$, 400 MHz): δ 1.65, 1.75, 1.76, 1.81 (each 3H, s), 3.39 (4H, br d, $J$ = 7 Hz), 3.47 (6H, s, -$OCH_2OC\underline{H}_3$ x 2), 3.50 (3H, s, -$OCH_2OC\underline{H}_3$), 4.96 (2H, s, -$OC\underline{H}_2OCH_3$), 5.33 (4H, s, -$OC\underline{H}_2OCH_3$ x 2), 5.23, 5.35 (each 1H, m), 6.48 (1H, s), 7.16 (1H, d, $J$ = 8 Hz), 7.58 (1H, dd, $J$ = 2 and 8 Hz), 7.59 (1H, d, $J$ = 2 Hz), 7.80 (2H,s), 12.99 (1H, s).

*Formation of 25 from 24*

A mixture of **24** (17 mg) and sodium acetate (42 mg) in EtOH (5 ml) was refluxed for 2h, and treated as usual. The product was purified by preparative tlc [*n*-hexane - acetone (7 : 1)] to give **25** (5 mg). Compound (**25**) was obtained as yellow oily substance. HR-ms: m/z 540.2699 ($M^+$, $C_{31}H_{40}O_8$ requires 540.2712). Ir $\nu_{max}^{KBr}$ $cm^{-1}$: 1670, 1600, 1160. $^1H$ Nmr (acetone-$d_6$, 400 MHz): δ 1.65, 1.71, 1.73, 1.78 (each 3H, s), 2.67 (1H, dd, $J$ = 3 and 17 Hz), 3.04 (1H, dd, $J$ = 13 and 17 Hz), 3.38,

3.39 (each 2H, br d, $J$ = 7 Hz), 3.45 (6H, s, -$OCH_2OC\underline{H}_3$ x 2), 3.53 (2H, s, -$OCH_2OC\underline{H}_3$), 5.01, 5.14 (each 1H, d, $J$ = 7 Hz, -$OC\underline{H}_2OCH_3$), 5.20 (1H, m), 5.27, 5.31 (each 2H, s, -$OC\underline{H}_2OCH_3$), 5.32 (1H, m), 5.47 (1H, dd, $J$ = 3 and 13 Hz), 6.51 (1H, s), 7.12 (1H, d, $J$ = 8 Hz), 7.34 (1H, dd, $J$ = 2 and 8 Hz), 7.35 (1H, d, $J$ = 2 Hz).

*Formation of 7 from 25*

A mixture of **25** (10 mg) and 3N HCl solution (0.2 ml) was refluxed for 30 min, and treated as usual. The product was purified by preparative tlc [*n*-hexane - acetone (2 : 1)] to give **7** (3 mg). The compound (**7**) was recrystallized from *n*-hexane - ethyl ether (1 : 1) to give pale yellow needles, mp 170 °C. The compound (**7**) was identified **7** by mixed melting point experiment and comparing the $^1$H nmr and ir spectral data.

*6-Prenylapigenin (9)*

Compound (**9**) was recrystallized from *n*-hexane - ethyl ether (1 : 1) to give yellow needles, mp 223 °C. HR-ms: *m/z* 338.1127 ($M^+$, $C_{20}H_{18}O_5$ requires 338.1149). $^1$H Nmr(acetone-$d_6$, 400 MHz): δ 1.65, 1.78 (each 3H, br s), 3.35 (2H, br d, $J$ = 7 Hz), 5.28 (1H, m), 6.61, 6.62 (each 1H, s), 7.02 (2H, d, $J$ = 9 Hz), 7.92 (2H, d, $J$ = 9 Hz), 13.30 (1H, s). $^{13}$C Nmr (acetone-$d_6$, 100 MHz): δ 161.9 (C-2), 104.1 (C-3), 183.2 (C-4), 105.3 (C-4a), 162.5 (C-5), 112.4 (C-6), 164.9 (C-7), 94.1 (C-8), 156.6 (C-8a), 123.5 (C-1'), 129.2 (C-2'and 6'), 116.9 (C-3' and 5'), 160.3 (C-4'), 20.0 (C-9), 123.3 (C-10), 131.7 (C-11), 25.9 (C-12), 17.9 (C-13).

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