Sesquiterpenoids of Ferula Species

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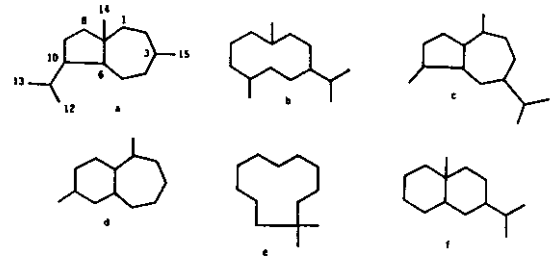
We are working now on the terpenoids of Ferula sinaica (Umbelliferae), and we have already isolated some new and known sesquiterpenes from Ferula sinaica [1]. In view of the scattered literature on the sesquiterpenes, we had great difficulty in checking the known sesquiterpenes. As a result, we have collected almost complete literature on the sesquiterpenes from Ferula species. An interesting pharmacological activity has been found recently in a number of sesquiterpenes. The extractives of some species of the genus Ferula have long been used as a folk medicine for treating various diseases [2]. For example, F.communis is already known in the ancient times [3,4] to be used as medicinal plants; used as antihysteric and for the treatment of dysentry. It is also mentioned [5] that the aerial parts of F.elaeochytris are added to the diet of sheep and cattle in Turkey to increase the fertility of these animals.

The plants of the genus Ferula are a rich source of coumarins and sesquiterpenes. With the exception of compound 3 (teferidine) which occurred once in the fruits of F.tenuisecta [6], all sesquiterpenes of Ferula species occurred in rhizomes and roots. These constituents have been reviewed in 1979 by Saidkhodzhaev [7]. This review was informative regarding the chemistry and biogenetic aspects of these natural compounds. However, the review was confined only on minor data such as MP, [α] and molecular formula; even the specific botanical source for any constituent has not been given. The present review deals with the physical and spectral data of the well known sesquiterpenes isolated from Ferula species during the period from 1979-up to the present time and in the same style as in our reviews [8-10] concerning the natural diterpenoids of Labiatae.

According to the chemical structure, Ferula sesquiterpenoids are divided to two groups: sesquiterpene alcohol esters and sesquiterpene lactones. So far, more than 90 sesquiterpenes have been isolated from Ferula species. Nearly, half of this number has been reviewed by Saidkhodzhaev [7]. The physical and spectral data of some sesquiterpenes encountered in the latter review will be listed in the present review if these sesquiterpenes occurred in new natural sources.

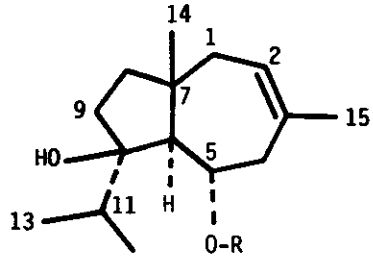
The sesquiterpenes thus far isolated from various Ferula species have the following skeletal types: carotane (a), germacrane (b), guaiane (c), himachalane (d), humulane (e) and selinane (f). However, the carotane derivatives seem to occur the most frequently in Ferula species.



Himachalane (d) is represented only by one compound isolated from Ferula xeromorpha [11]. The common acids which esterify the sesquiterpene alcohols are: veratric, vanillic, p-hydroxybenzoic, benzoic, angelic, isovanillic, senecinoyl and acetic acids.

UV spectra measured in methanol unless otherwise stated. NMR chemical shift data are in ppm on the δ scale, using $CDCl_3$ as a solvent. ^{13}C NMR figures are listed in Tables for the structurally related compounds to allow ready comparison to all those interested in the field.

1. Jaeschkeanadiol



$C_{15}H_{26}O_2$
(Structure 1, R = H)

MP : 91-92° [21].

[α] : + 38.8° [21].

MS : 220 (M^+-18.5%), 205 (6), 195 (100), 177 (98), 159 (40), 151 (55), 123 (35), 93 (32), 41 (67) [21].

^1H NMR ($CDCl_3$): 0.88 and 0.91 (each 3H, d, J = 7Hz, H-12 and H-13), 1.00 (3H, s, H-14), 1.80 (3H, br s, H-15), 3.8 (1H, m, H-5), 5.4 (1H, t, J = 6Hz, H-2) [21].

^{13}C-NMR : Table 1 [5].

SOURCES : F. communis subsp. communis [19], F. Jaeschkeana Vatke [16,21], F. linkii Webb [18], F. sinaica [1].

2. Angeloyl of jaeschkeanadiol

(Structure 1, R = angeloyl)

amorphous oil

UV : 218 nm [5].

IR(KBr) : 3500 (OH), 2960, 2860, 1705 (C=O), 1645, 1450, 1270, 1150, 1030, 1000, 940, 705, 660 [5].

MS : M^+ not observed, 277 (M-43.8%), 83 angelate, 75), other fragments from jaeschkeanadiol moiety included; 220 (jaeschkeanadiol-OH $-H^+$, 15), 202 (jaeschkeanadiol-2(OH+H, 20), 177 (jaeschkeanadiol-43-18,90 [5].

SOURCE : F. elaeochytris Korovin [5].

3. Teferidine

$C_{22}H_{30}O_3$
(Structure 1, R = benzoyl)

MP : 78-80° [6].

[α] : + 86.5° [6].

^1H NMR : 0.85 and 0.96 (each 3H, d, J = 7Hz, H-12 and H-13), 1.12 (3H, s, H-14), 1.85 (3H, br s, H-15), 5.32 (1H, dt, J = 3 and 10 Hz, H-5), 5.56 (1H, br t, J = 6.5 Hz, H-2), 7.46 (2H, dt, J = 2 and 9Hz, H-2 and H-6), 7.6 (1H, dt J = 2 and 9Hz, H-4), 8.03 (2H, dd, J = 2 and 9Hz, H-3 and H-5) [5].

SOURCES : F. elaeochytris [5], F. tenuisecta [6].

4. Ferutinin

$C_{22}H_{30}O_4$
(Structure 1, R = p-hydroxybenzoyl)

MP : 120-121° [12,13].

[α] : 66.1°

^{1}H NMR : 0.90 (6H, apparent t, J = 6Hz), 1.10 (3H, s, H-14), 1.80 (3H, br s, H-15), 5.15 (1H, t, J = 11Hz, H-5), 5.55 (1H, br s, H-2), 6.92 and 7.92 (each 2H, d, J = 9Hz) [14].

SOURCES : F. elaeochytris [5], F. jaeschkeana Vatke [16], F. lancerottensis Parl [14], F. ovina [15], F. communis L. [23].

5. Ferutidin

$C_{23}H_{32}O_4$
(Structure 1, R = p-anisoyl)

MP : 102-103° [17].
106-108° [1].

[α] : + 103.5° [17]

MS : M^+ not observed, 329.1771 ($M-C_3H_7$, 9% ; calculated for $C_{20}H_{25}O_4$ 329.1725), 220 (3), 202 (2), 177 (43), 159 (37) [18].

^{1}H NMR : 0.83 and 0.93 (each 3H, d, J = 7Hz), 1.10 (3H, s, H-14), 1.81 (3H, br s, H-15), 3.85 (3H, s, OMe), 5.30 (1H, sx, J = 3 and 11Hz), 5.57 (1H, complex signals), 6.95 and 7.98 (each 2H, d, J = 9Hz) [18].

^{13}C NMR : Table 1 [19]

SOURCES : F. communis subsp. communis [19], F. elaeochytris [5], F. kuhistanica 17, F. linkii [17], F. sinaica [1].

6. 5-Salicylate of jaeachkeanadiol

$C_{22}H_{30}O_4$ (amorphous).
(Structure 1, R = salicyloyl)

UV : 340, 280 sh, 249, 220 nm [5].

IR (KBr) : 3470 (OH), 3360 (OH), 2890, 2880, 1680, 1610, 1585, 1550, 1480, 1375, 1295, 1235, 1160, 1095, 950, 750, 700 cm^{-1} [5].

MS : 358 (M^+, 85%), 340 (M-OH+H,5), 315 (M-43,88), 220 (20), 202 (40), 137 (salicylic acid-1, 95), 121 (salicyloyl acylium ion, 100) [5].

^{1}H NMR : 7.07 (1H, dt, J = 2 and 8Hz, H-4'), 7.52 (1H, dt, J = 2 and 8Hz, H-5'), 7.94 (1H, dd, J = 2 and 9Hz, H-3'), 8.65 (1H, dd, J = 2 and 9Hz, H-6'), remaining signals are similar to those of compound 3 [5].

Acetate derivative :

MP : 168-170 (MeOH) [5].

^{13}C NMR : Table 1 [5].

SOURCE : F. elaeochytris Korovin [5].

7. Teferin

$C_{23}H_{32}O_5$
(Structure 1, R = vanilloyl)

MP : 78-80° [20].

[α] : + 86.5° [20].

Original literature not available to the reviewer [20].

^{1}H NMR : 3.9 (3H,s,Ome), 6.9(1H,d,J = 8 Hz,H-5'), 7.6 (2H, br d, J = 8 Hz, H-2' and H-6'), other signals as in compound 3 [5].

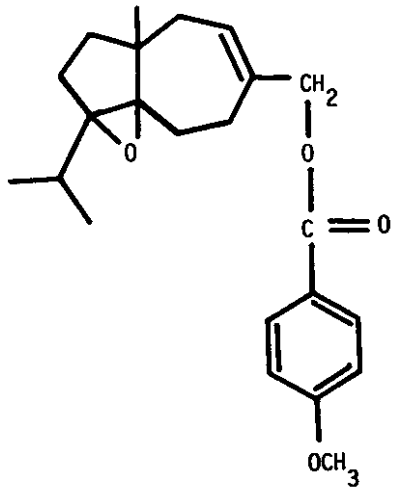
SOURCE : F. elaeochytris Korovin [5], F. tenuisecta [20], F. Jaeschkeana Vatke [16].

8.

$C_{23}H_{30}O_4$
Gum

UV($CHCl_3$): 259 nm [19].

IR(KBr) : 2960, 2940, 2880, 1710, 1648, 1608, 1580, 1512, 1455, 1372,



1319, 1260, 1170, 1104, 1036, 850, 772 cm^{-1} [19].

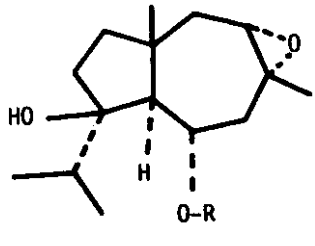
MS : 370 (M^+, 49.8%), 355 (M-Me, 10.1), 327 (M-iso-Pr, 6.4), 289 (11.4), 271 (14.3), 218 (M-p-anisic, 78.3), 203 (53.5), 175 (67.4), 152 (p-anisic acid, 86.4), 135 (p-anisate, 100), 121 (59), 107 (64.4), 92 (60.7) [19].

^1H NMR : 0.91 (3H,s,H-14), 0.94 (3H, d, J = 6.5Hz, H-12), 1.07 (3H, d, J = 6.5Hz, H-13), 3.87 (3H, s, OMe), 4.73 (2H, br s, H-15), 5.87 (1H, br t, H-2), 6.93 (2H, d, J = 8Hz), 8.1 (2H, d, J = 8Hz) 19.

^{13}C NMR : Table 1 [19] .

SOURCE : F. communis subsp. communis [19].

9. Isovalerate of epoxy-jaeschkeanadiol



(Structure 9, R = isovaleroyl)

MP : 86-88° [18].

IR : 3640, 3000, 2950, 2860, 1715, 1640, 1380, 1290, 1185, 1100, 1030, 980, 960, 870 cm^{-1} (18).

MS : 338 (M^+, 0.7%), 295.1907 ($M-C_3H_7$, 1%, calculated for $C_{17}H_{27}O_4$ 295.1909), 236 (3), 193 (46), 175 (54), 165 (15), 151 (26) [18].

^1H NMR : 0.75-1.11 (12H, complex signal), 1.19 and 1.43 (each 3H, s), 2.83 (1H, t, J = 9Hz, H-2), 5.17 (1H, sx, J = 2 and 11Hz, H-5) [18].

SOURCE : F. linkii Webb [18].

10. p-Hydroxybenzoate of epoxyjaeschkeanadiol

(Structure 9 R = p-hydroxybenzoyl)

MP : 133-134° [14].

IR : 3600, 3350, 2970, 2890, 1695, 1620, 1590, 1515, 1450, 1385, 1310, 1270, 1170, 1120, 1100, 960, 920, 850 cm^{-1} [14].

MS : M^+ not observed, 345 ($M-C_3H_7$), 234, 207, 191, 163, 151, 148 [14].

^1H NMR : 0.88 (6H, t, J = 8Hz), 1.26 (3H, s, H-14), 1.48 (3H, s, H-15), 2.93 (1H, t, J = 8Hz), 5.48 (1H, t, J = 11Hz, H-5) [14].

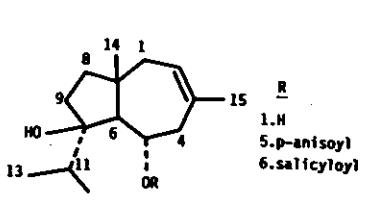
SOURCE : F. lancerottensis Parl. [14].

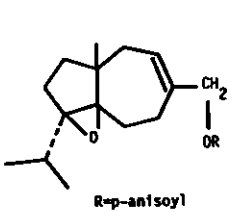
11. p-Methoxybenzoate of epoxyjaeschkeanadiol

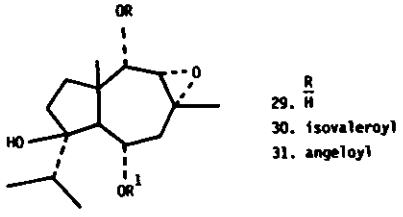
(Structure 9, R = p-anisoyl)

MP : 145-148° [18].

Table-1: ^{13}C-NMR data of Jaeschkeanadiol (1), Ferutidin (5), 5-Salicylate of jaeskeanadiol (6), and Compounds 8, 29-31.







Carbon No.	1	5	6	8	29	30	31
1	41.2 t	41.4 t	41.1 t	33.3 t	71.4	71.4	71.5
2	129.1 d	125.3 d	125.5 d	127.2 d	60.0	59.7	59.7
3	133.6 s	133.6 s	134.5 s	138.1 s	56.6	56.0	56.0
4	43.0 t	41.4 t	41.4 t	22.7 t	45.7	42.5	42.8
5	67.9 d	71.0 d	71.8 d	24.7 t	67.3	69.2	69.1
6	36.1 d	60.0 d	36.8 d	76.0 s	53.4	51.0	51.4
7	45.2 s	44.0 s	44.1 s	41.9 s	46.5	47.1	47.3
8	32.3 t	31.6 t	32.8 t	23.4 t	31.6	31.4	31.1
9	42.1 t	41.1 t	41.1 t	28.0 t	37.1	36.6	36.5
10	87.1 s	86.2 s	86.2 s	76.8 s	85.8	85.2	85.4
11	61.9 d	37.2 d	59.7 d	33.9 d	38.4	37.2	37.2
12	17.2 q	17.5 q	17.5 q	17.8 q	17.0	17.1	17.2
13	18.4 q	18.5 q	18.6 q	18.2 q	18.2	18.3	18.3
14	19.8 q	20.3 q	20.1 q	20.3 q	17.8	17.8	17.9
15	27.7 q	26.4 q	26.5 q	69.3 t	24.3	23.2	23.3
		166.4,163.4	168.0,25.4,	165.6s,162.9s			
		131.0,123.0	169.2,141.9	131.0d,122.3s			
		113.8,55.3	133.3,130.3	113.1d,54.7q			
			122.3,120.2				

IR : 3460, 3000, 2960, 2850, 1700, 1600, 1505, 1455, 1380, 1310, 1255, 1160, 1100, 1030, 955, 875, 845 cm^{-1} [18].

MS : 388.2229 (M^+, 0.2%, calculated for $C_{23}H_{32}O_5$ 388.2249), 345 (5), 327 (0.3), 236 (1), 193 (10), 175 (5), 152 (23), 135 (100) [18].

^{1}H NMR : 0.90 (6H, t, J = 8Hz), 1.30 and 1.51 (each 3H, s), 2.90 (1H,t), 3.91 (3H, s, OMe), 5.48 (1H, t, J = 11Hz), 6.96 and 7.98 (each 2H, d, J = 9Hz) [18].

SOURCE : F. linkii Webb [18].

12. Veratrate of epoxy-jaeschkeanadiol

$C_{24}H_{34}O_6$
(Structure 9, R = veratroyl)

MP : 187-190° [18].

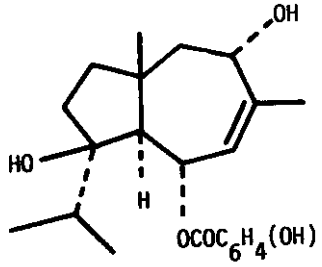
IR : 3470, 3000, 2950, 2860, 1695, 1595, 1505, 1460, 1410, 1370, 1265, 1170, 1130, 1100, 1020, 955, 870 cm^{-1} [18].

MS : 418.2350 (M^+, calculated for $C_{24}H_{34}O_6$ 418.2355), 375, 279, 236, 234, 219, 193 [18].

^{1}H NMR : 0.96 (6H, t, J = 6Hz), 1.29 and 1.50 (each 3H,s), 2.90 (1H, t, J = 9Hz), 3.92 and 3.95 (each 3H,s), 5.47 (1H, sx, J = 2 and 11Hz), 6.93 (1H, d, J = 9Hz), 7.58 (1H, d, J = 2Hz), 7.77 (1H, d, J = 2Hz) [18].

SOURCE : F. linkii Webb [18].

13. p-Hydroxybenzoate of lancerotriol

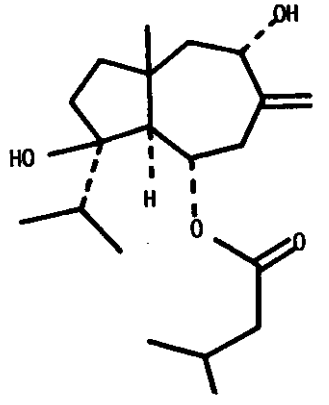


MS : M^+ not observed, 338.1895 ($M-2H_2O$, calculated for $C_{22}H_{26}O_3$ 338.1882), 236, 218, 193, 175, 157, 151 [14].

^{1}H NMR : 0.87 (6H, t, J = 6Hz), 1.17 (3H, s, H-14), 1.88 (3H, br s, H-15), 2.23 (1H, d, J = 11Hz, H-6), 4.32 (1H, br, H-2), 5.40 (1H, br s, H-4), 5.87 (1H, d, J = 11Hz, H-5), 6.90 and 7.94 (each 2H, d, J = 9Hz) [14].

SOURCE : F. lancerottensis Parl. [14].

14. 5-Isovalerate of isolancerotriol



MP : 84-86° (petrol) [22].

IR : 3580, 3450, 3000, 2940, 2920, 2860, 1700, 1460, 1380, 1290, 1230, 970, 910 [22].

MS : 295.1941 ($M-C_3H_7$, $C_{17}H_{27}O_4$ requires 295.1909), 284 (2%), 236 (6), 218 (5), 203 (5), 201 (3), 193 (39), 175 (100) [22].

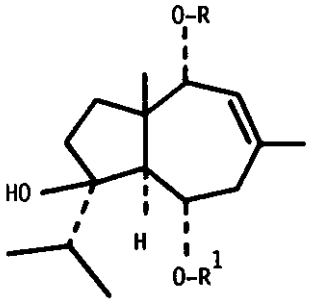
^{1}H NMR : 0.80-1.03 (12H, complex signal), 1.12 (3H, s, H-14), 1.91 (1H, d, J = 10Hz, H-6), 2.48 and 2.55 (each 1H, dd, J = 5 and 14Hz), 4.20 (1H, dd, J = 6 and 11Hz, H-2), 5.00 and 5.23 (each 1H, br s, H-15), 5.23 (1H, m, H-5) [22].

^{1}H NMR(C_6D_6): 0.76-0.94 (12H, complex signal), 1.04 (3H, s, H-14), 2.43 and 2.55 (each 1H, dd, J = 14 and 5Hz, H-4), 3.86 (1H, dd, J = 11, 6Hz, H-2), 5.01 and 5.22 (each 1H, s, H-15), 5.52 (1H, dt, J = 10 and 5Hz, H-5) [22].

^{13}C NMR : Table 2 [22].

SOURCE : F. linkii Webb [22].

15. 1-Acetate-5-isovalerate of ferulinkiol



(Structure 15, R=Ac,R^1=isovaleroyl)

IR : 3590, 3000, 2960, 2920, 2860, 1720, 1460, 1370, 1290, 1250, 1190, 1020, 980, 950 [18].

MS : M^+ not observed, 337 ($M-C_3H_7$, 0.2%), 295 (0.2), 277.1761 ($M-C_3H_7-AcOH$, 1.4; calcd. for $C_{17}H_{25}O_3$ 277.1803), 264 (0.7), 251 (0.6), 235 (8), 218 (14), 193 (14), 175 (100), 157 (20), 147 (30), 132 (100) [18].

^1H NMR : 0.98 (12H, complex signal), 1.13 and 1.82 (each 3H,s), 2.06 (3H,s), 2.62 (1H, d, J = 11Hz), 4.88 (1H, d, J = 7Hz), 5.18 (1H, sx, J = 3 and 11Hz), 5.70 (1H, d, J = 7Hz) [18].

SOURCE : F. linkii Webb [18].

16.

$C_{23}H_{32}O_5$

(Structural 15, R=H, R^1=p-anisoyl) Gum

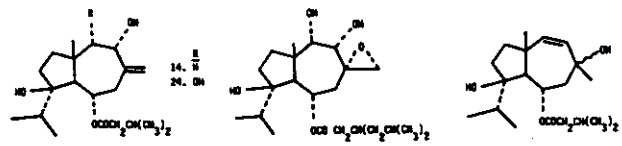
$UV(CHCl_3)$: 260 nm [19].

IR(KBr) : 3480, 2978, 2935, 2875, 1700, 1605, 1580, 1505, 1450, 1378, 1260, 1150, 1100, 1030, 950, 840, 765, 690 cm^{-1} [19].

MS : 388 (M^+, 0.2%), 345 ($M-C_3H_7$, 14.1), 327 ($M-C_3H_7-H_2O$, 23.1), 236 (M-p-anisic acid 47), 203 (M-p-anisic-H_2O-Me, 15.6), 201 (M-p-anisic-2xH_2O+H, 15.6), 193 (M-p-anisic-C_3H_7, 51.3), 175 (83.4), 157 (47.7), 152 (p-anisic, 71.5), 135 (p-anisate, 100), 119 (61.1), 107 (64.9), 92 (55.1) [19].

^1H NMR : 0.86 and 0.99 (each 3H, d, J = 6.5Hz, H-12, H-13), 1.14 (3H,

Table-2: ^{13}C-NMR data of 5-Isovalerate of isolancerotriol(14), 5-Isovalerate of isolancerotetrol(24), 5-Isovalerate of ferutriol(26) and Isovalerate of epoxyisolancerotetrol(33).



Carbon No.	14	24	33	26
1	51.1	74.1	75.7	134.2
2	72.3	77.1	71.1	140.9
3	148.6	143.6	56.2	71.3
4	42.9	40.4	40.4	50.8
5	72.9	71.6	69.3	67.6
6	55.6	45.0	45.3	55.8
7	42.2	46.3	47.4	44.7
8	32.0	31.7	31.8	32.0
9	39.5	36.8	36.8	41.4
10	85.9	86.4	86.7	86.3
11	36.9	37.0	37.0	38.0
12	17.4	17.6	17.7	17.3
13	18.5	18.3	18.4	18.5
14	20.6	21.2	21.8	21.8
15	113.8	115.1	48.2	32.0
ester	174.4,44.2, 25.8,22.6, 22.6.	173.3,44.1, 25.7,22.5.	173.1,44.0, 25.7,22.6, 22.6.	

MS : M^+ not observed, 337 ($M-C_3H_7$, 0.2%), 295 (0.2), 277.1761 ($M-C_3H_7-AcOH$, 1.4; calcd. for $C_{17}H_{25}O_3$ 277.1803), 264 (0.7), 251 (0.6), 235 (8), 218 (14), 193 (14), 175 (100), 157 (20), 147 (30), 132 (100) [18].

^1H NMR : 0.98 (12H, complex signal), 1.13 and 1.82 (each 3H,s), 2.06 (3H,s), 2.62 (1H, d, J = 11Hz), 4.88 (1H, d, J = 7Hz), 5.18 (1H, sx, J = 3 and 11Hz), 5.70 (1H, d, J = 7Hz) [18].

SOURCE : F. linkii Webb [18].

16.

$C_{23}H_{32}O_5$

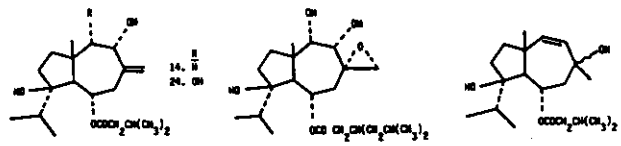
(Structural 15, R=H, R^1=p-anisoyl) Gum UV($CHCl_3$): 260 nm [19].

IR(KBr) : 3480, 2978, 2935, 2875, 1700, 1605, 1580, 1505, 1450, 1378, 1260, 1150, 1100, 1030, 950, 840, 765, 690 cm^{-1} [19].

MS : 388 (M^+, 0.2%), 345 ($M-C_3H_7$, 14.1), 327 ($M-C_3H_7-H_2O$, 23.1), 236 (M-p-anisic acid 47), 203 (M-p-anisic-H_2O-Me, 15.6), 201 (M-p-anisic-2xH_2O+H, 15.6), 193 (M-p-anisic-C_3H_7, 51.3), 175 (83.4), 157 (47.7), 152 (p-anisic, 71.5), 135 (p-anisate, 100), 119 (61.1), 107 (64.9), 92 (55.1) [19].

^1H NMR : 0.86 and 0.99 (each 3H, d, J = 6.5Hz, H-12, H-13), 1.14 (3H,

Table-2: ^{13}C-NMR data of 5-Isovalerate of isolancerotriol(14), 5-Isovalerate of isolancerotetrol(24), 5-Isovalerate of ferutriol(26) and Isovalerate of epoxyisolancerotetrol(33).



Carbon No.	14	24	33	26
1	51.1	74.1	75.7	134.2
2	72.3	77.1	71.1	140.9
3	148.6	143.6	56.2	71.3
4	42.9	40.4	40.4	50.8
5	72.9	71.6	69.3	67.6
6	55.6	45.0	45.3	55.8
7	42.2	46.3	47.4	44.7
8	32.0	31.7	31.8	32.0
9	39.5	36.8	36.8	41.4
10	85.9	86.4	86.7	86.3
11	36.9	37.0	37.0	38.0
12	17.4	17.6	17.7	17.3
13	18.5	18.3	18.4	18.5
14	20.6	21.2	21.8	21.8
15	113.8	115.1	48.2	32.0
ester	174.4,44.2, 25.8,22.6, 22.6.	173.3,44.1, 25.7,22.5.	173.1,44.0, 25.7,22.6, 22.6.	

s, H-14), 1.84 (3H, br s, H-15), 2.27 (1H, dd, J = 3.8 and 14.5Hz, H-4β), 2.83 (1H, d, J = 10.5Hz, H-6), 3.86 (1H, d, J = 7Hz, H-1), 3.88 (3H, s), 5.44 (1H, dt, H-5), 5.76 (1H, d, J = 7Hz, H-2), 6.94 and 7.98 (each 2H) [19].

SOURCE : F. communis subsp. communis [19].

17.

$C_{25}H_{34}O_6$

(Structure 15,R=Ac,R=p-anisoyl) Gum.

UV ($CHCl_3$): 262 nm [19].

IR(KBr): 3480, 2960, 2930, 2880, 1720 sh, 1710, 1608, 1585, 1510, 1458, 1375, 1258, 1170, 1120, 1103, 1030, 960, 850, 772, 718 cm^{-1} [19].

MS : 430 (M^+, 0.17%), 387 (M-C_3H_7, 3.4), 327 (M-AcOH-C_3H_7, 15.9), 218 (M-p-anisic-AcOH, 32.6), 175 (M-p-anisic-AcOH-C_3H_7, 90.3), 157 (38.1), 152 (p-anisic acid, 64.6), 147 (58.4), 135 (p-anisate, 100), 43 (94) [19].

^1H NMR : 0.86 and 0.99 (each 3H, d, J = 6.5Hz, H-12 and H-13), 1.19 (3H, s, H-14), 1.82 (3H, br s, H-15), 2.09 (3H,s), 2.26 (1H, dd, J = 2.5 and 14.5Hz, H-4β), 2.76 (1H, d, J = 10.5Hz, H-6), 3.88 (3H, s, OMe), 4.9 (1H, d, J = 6.5Hz, H-1), 5.42 (1H, dt, 2.5, 9.5 and 10.5Hz, H-5), 5.72 (1H, br d, J = 6.5Hz, H-2), 6.94 and 8.0 (each 2H, d, J = 8.5Hz) [19].

SOURCE : F. communis subsp. communis [19].

18.

$C_{27}H_{36}O_5$

(Structure 15,R=angeloyl,R^1=benzoyl) Gum.

UV ($CHCl_3$) : 246, 274, 282 sh nm [19].

IR(KBr): 3510, 2962, 2940 sh, 2880, 1710, 1650, 1605, 1588, 1455, 1388, 1320, 1278, 1238, 1162, 1120, 1045, 989, 960, 850, 714 [19].

MS : 440 (M^+, 0.3), 423 (M-H_2O+H, 9.4), 341 (M-angelic acid + H, 5.8), 323 (M-angelic acid - H_2O + H, 17.5), 319 (M-C_6H_5COOH-H, 12.7), 301 (M-C_6H_5COOH-H_2O + H, 7.63), 297 (M-angelic acid-C_3H_7-14.4), 279 (M-angelic acid-C_3H_7-H_2O, 4.6), 275 (M-C_6H_5COOH-C_3H_7, 28.1), 257 (15.4), 235 (M-C_6H_5COOH-angelate, 29.2), 219 (M-C_6H_5COOH-angelic acid+H, 53.1), 201 (90.1), 175 (M-C_6H_5COOH-angelic acid-C_3H_7, 100), 132 (32.8), 122 (C_6H_5COOH, 32.3), 105 (benzoate, 29.2), 83 (angelate, 70.5) [19].

^1H NMR : 0.84 and 0.99 (each 3H, d, J = 6.5Hz, H-12 and H-13), 1.23 (3H, s, H-14), 1.83 (3H, br s, H-15), 1.98 (3H, t, H-5"), 2.05 (3H, dd, J = 1 and 6.5Hz, H-4"), 2.25 (1H, dd, J = 2.5 and 15Hz, H-4β), 2.81 (1H, d, J = 10.5Hz, H-6), 4.95 (1H, d, J = 6.5Hz, H-1), 5.48 (1H, dt, J = 2.5, 9.5 and 10.5Hz, H-5), 5.8 (1H, br d, J = 6.5Hz, H-2), 6.12 (1H, dq, H-3"), 7.46 (2H, dt, J = 1 and 8.5Hz), 7.58 (1H, td, J = 1 and 8.5Hz), 8.07 (2H, dd, J = 1 and 8.5Hz) [19].

^{13}C NMR : Table 3 [19].

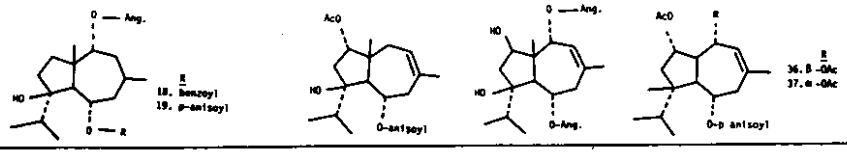
SOURCE : F. communis subsp. communis [19].

19.

$C_{28}H_{38}O_6$

(Structure 15,R=angeloyl, R^1=p-anisoyl) Gum.

Table-3: ^{13}C-NMR data of compounds 18, 19, 23, 34, 36 and 37.



Carbon No.	18	19	23	34	36	37
1	75.5 d	74.4	34.9 t	69.8 d	75.1 d	75.1
2	124.6 d	124.5	124.6 d	139.4 d	128.6 d	125.5
3	137.4 s	137.4	133.9 s	127.7 s	131.6 s	135.4
4	37.4 t	37.3	39.7 t	38.3 t	39.4 t	39.0
5	71.5 d	71.0	70.4 d	71.0 d	69.5 d	70.0
6	51.5 d	51.5	55.9 d	49.3 d	55.5 d	49.1 d
7	46.8 s	46.7	37.3 s	48.6 s	51.1 s	49.1 s
8	31.2 t	30.9	82.8 d	73.2 d	79.3 d	80.6
9	40.5 t	40.5	40.8 t	40.5 t	41.1 t	39.9
10	86.2 s	86.1	85.1 s	81.2 s	85.7 s	84.0
11	37.4 d	37.3	37.0 d	36.7 d	37.1 d	36.8
12	18.5 d	18.5	18.2 q	15.5 q	18.1 q	18.2
13	17.4 q	17.4	17.6 q	15.5 q	17.5 q	17.6
14	21.0 q	21.0	20.5 q	13.3 q	21.0 q	21.2
15	27.3 q	27.3	25.9 q	27.4 q	26.0 q	26.0
ester(Ali.)	166.6,128.1, 138.5, 20.7, 15.8	166.4,127.9, 138.3,20.6, 15.8				
(Ar.)	167.2,133.2, 130.7,129.8, 128.6	167.2,163.8, 131.8,122.8, 113.9, 55.4				

UV ($CHCl_3$): 261 nm [19].

IR(KBr): 3510, 2980, 2940, 2882, 1710, 1660, 1610, 1583, 1516, 1464, 1445, 1428, 1380, 1320, 1305, 1263, 1172, 1120, 1108, 1040, 960, 936, 853 [19].

MS : 470 (M^+, 0.1%), 427 (M-C_3H_7, 0.51), 327 (M-angelic acid-C_3H_7, 18.9), 275 (M-p-anisic-C_3H_7, 12.5), 257 (M-p-anisic-C_3H_7-H_2O, 3.93), 235 (M-p-anisic acid - angelic acid, 57.6), 203 (22.2), 201 (M-p-anisic acid-angelic acid - H_2O, 26.5), 175 (M-p-anisic acid-angelic acid-CH, 91.5), 157 (51.3), 152 (p-anisic acid, 66.8), 147 (53.2), 135 (p-anisate, 100), 83 (angelate, 72.3) [19].

^{1}H NMR : 0.85 and 0.97 (each 3H, d, J = 6.5Hz, H-12 and H-13), 1.22 (3H, s, H-14), 1.81 (3H, br s, H-15), 1.98 (3H, t, J = 1Hz, H-5"), 2.05 (3H, dd, J = 1 and 6.5Hz, H-4"), 2.24 (1H, dd, J = 2.5 and 14.5Hz, H-4β), 2.79 (1H, d, J = 10.5Hz, H-6), 3.88 (3H,s,OMe), 4.94 (1H,d, J=7.5Hz,H1), 5.44 (1H, br d, J = 2.5, 9.5 and 10.5Hz, H-5), 5.79 (1H, br d, J = 7.5Hz, H-2), 6.11 (1H, dq, H-3"), 6.95 and 7.98 (each 2H, d, J = 8.5Hz) [19].

^{13}C NMR: Table 3 [19].

SOURCE : F. communis subsp. communis [19].

20.

$C_{29}H_{40}O_7$

(Structure 15, R=angeloyl, R^1= veratroyl) Gum.

UV ($CHCl_3$): 265, 295 nm [19].

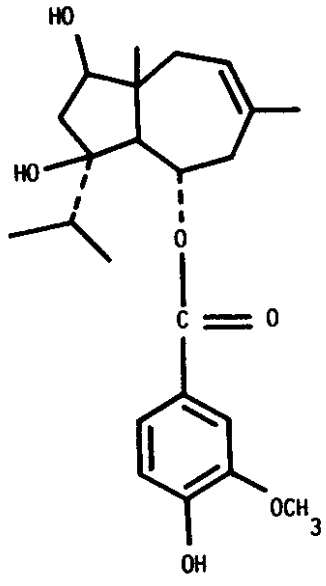
IR($CHCl_3$): 3460, 2970, 2935, 2885, 1710sh, 1703, 1660, 1640, 1608, 1580, 1560, 1548, 1515, 1462, 1440, 1425, 1385, 1350, 1272, 1260, 1140, 1120, 1068, 1040, 960, 935, 880, 850 [19].

MS : 500 (M^+, 0.24%), 483 (M-H_2O+H, 4.1), 401 (M-angelic acid + H, 2.7), 383 (M-angelic acid-H_2O + H, 8.6), 357 (M-angelic acid-C_3H_7, 32.9), 319 (M-veratric acid + H, 3.6), 275 (M-veratric acid-C_3H_7, 16.3), 257 (7.2), 235 (M-veratric acid-angelate, 45.6), 218 (M-veratric acid-angelic acid, 55.2), 201 (59.8), 182 (veratric acid, 90.3), 175 (M-veratric acid C_3H_7, 86.4), 165 (veratrate, 100), 157 (58.6), 132 (77.3), 121 (50.9), 119 (74.9), 107 (64.9), 83 (angelate, 70.6) [19].

^1H NMR : 0.87 and 0.99 (each 3H, d, J = 6.5Hz, H-12 and H-13), 1.23 (3H, s, H-14), 1.83 (3H, br s, H-15), 1.97 (3H, t, J = 1Hz, H-5"), 2.05 (3H, td, J = 1 and 7Hz, H-4"), 2.27 (1H, dd, J = 2.5 and 14.5Hz, H-4), 2.8 (1H, d, J = 10.5Hz, H-6), 3.93 and 3.96 (each 3H, s, 2 x OMe), 4.94 (1H, d, J = 7.5Hz, H-1), 5.79 (1H, br d, J = 7.5Hz, H-2), 6.11 (1H, dq, H-3"), 7.54 (1H, br d, J = 2Hz), 7.68 (1H, dd, J = 2 and 8.5Hz) [19].

SOURCE : F. communis subsp. communis [19].

21. Jaeschferin

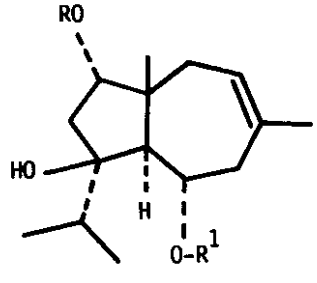


Mass and NMR spectra were used to determine its structure [24].

Literature not available to the reviewer [24].

22.

(Structure 22, R=Ac, R^1=benzoyl) Gum.



UV ($CHCl_3$): 273, 285 sh nm [19].

IR($CHCl_3$): 3480, 2980, 2940, 2882, 1720, 1710, 1608, 1582, 1510, 1450, 1380, 1320, 1300, 1260, 1120, 1075, 1032, 732 cm^{-1} [19].

MS : 357 ($M-C_3H_7$, 20.4), 297 ($M-C_3H_7$-AcOH, 29.1), 218 ($M-C_6H_5COOH$-AcOH, 46.2), 175 ($M-C_6H_5COOH$-AcOH-C_3H_7, 46.2), 157 (29.5), 147 (67.8), 122 (C_6H_5COOH, 20.9), 105 (benzoate, 95), 43 (64.6) [19].

^1H NMR : 0.81 and 0.96 (each d, J = 6.5Hz, H-12 and H-13), 1.13 (3H, s, H-15), 1.84 (3H, br s, H-15), 2.07 (3H,s), 2.28 (1H, dd, J = 2.1 and 15Hz, H-4,), 2.53 (1H, d, J = 10.5Hz, H-6), 4.89 (1H, d, J = 5.1Hz, H-8), 5.47 (1H, br t, H-2), 7.48 (2H, dt, J = 1 and 8.5Hz), 7.59 (1H, td, J = 1 and 8.5Hz), 8.04 (2H, dd, J = 1 and 8.5Hz) [19].

SOURCE : F. communis subsp. communis [19].

23.

(Structure 22, R=Ac, R^1=p-anisoyl) Gum.

UV ($CHCl_3$): 261 nm [19].

IR($CHCl_3$): 3480, 2980, 2960, 2890, 1725, 1710, 1610, 1585, 1515, 1382, 1308, 1260, 1175, 1108, 1038, 952, 938, 855 [19].

MS : 387 ($M-C_3H_7$, 13.9), 327 ($M-AcOH-C_3H_7$, 7.4), 218 (M-AcOH-p-anisic acid, 32.2), 203 (8), 175 (M-AcOH-p-anisic acid-C_3H_7, 91.5), 157 (16.3), 152 (p-anisic acid, 45.2), 147 (53.1), 135 (p-anisate, 100%), 132 (75.2), 121 (38.1), 105 (61.3), 92 (43.4) [19].

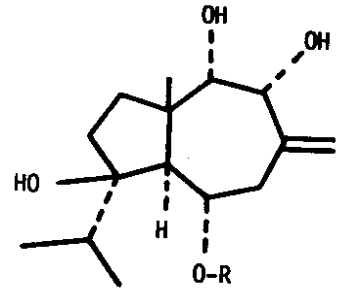
^1H NMR : 0.81 and 0.94 (each 3H, d, J = 6.5Hz, H-12 and H-13), 1.13 (3H, s, H-14), 1.82 (3H, br s, H-15), 2.07 (3H, s), 2.27 (1H, dd, J=2.5 and 14.5Hz, H-4), 2.51 (1H, d, J = 10.5Hz, H-6), 3.88 (3H, s, OMe), 4.89 (1H, d, J = 4.8Hz, H-8), 5.33 (1H, dt, J = 2.5, 9.5 and 10.5Hz, H-5), 6.95 and 7.99 (each 2H, d, J = 8.5Hz) [19].

^{13}C NMR : Table 3 [19].

SOURCE : F. communis subsp. communis [19].

24. 5-Isovalerate of isolancerotetrol

(Structure 24, R = isovaleroyl)



IR($CHCl_3$): 3580, 3460, 3070, 3000, 2950, 2920, 2860, 1705, 1640, 1460, 1380, 1365, 1290, 1230, 1160, 1050, 975, 910, 830 [22].

MS : M^+ not observed, 311 ($M-C_3H_7$, 2%), 252 (2), 234 (10), 209 (27), 191 (59), 173 (16), 163 (13) [22].

^1H NMR : 0.90 and 0.92 (each 3H, d, J = 2.7Hz), 0.97 and 0.99 (each 3H, d, J = 3 Hz), 1.20 (3H, s, H-14), 3.68 and 4.31 (each 1H, d, J = 3 Hz, H-1 and H-2), 5.08 and 5.27 (each 1H, s, H-15), 5.32 (1H, ddd, J = 2,4 and 10 Hz, H-5) [22].

^{13}C NMR : Table 2 [22].

SOURCE : F.linkii Webb [22].

25. 5-Angelate of isolancerotetrol

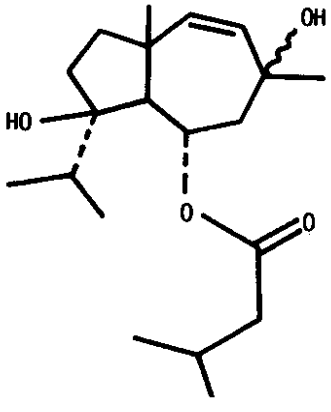
(Structure 24, R = angeloyl) 1 characterized as its corresponding acetonide 2

^{1}H NMR: 0.80 and 1.02 (6H, complex signal), 4.11 and 4.57 (each 1H, d, J = 8.0 Hz, H-1 and H-2), 5.19 (2H, br s, H-15), 5.19 (1H, m, H-5), 6.07 (1H, m, Ang.) [22].

MS : 377.2327 (M-Me, 6%; $C_{22}H_{33}O_5$ requires 377.2328), 349 (6), 292 (4), 274 (4), 249 (20), 234 (20), 217 (13), 191 (97), 173 (2) [2].

SOURCE : F. linkii Webb [22].

26. 5-Isovalerate of ferutriol



MP : 54-56° (petrol) [25].

IR : 3580, 3440, 3000, 2950, 2860, 1705, 1460, 1380, 1365, 1290, 1160, 1090, 1025, 900 [25].

^{1}H NMR : 0.80-1.09 (12H, complex signal), 1.23 and 1.49 (each 3H, s, H-14 and H-15), 5.50 (2H, d, J = 2H, H-1 and H-2), 5.59 (1H, br d, H-5).

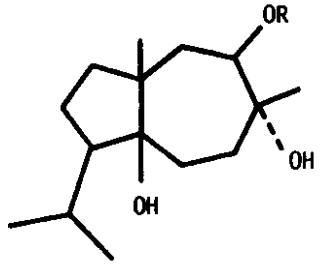
^{1}H NMR(C_6D_6): 0.78-1.06 (12H, complex signal), 1.29 and 1.57 (each 3H, s), 5.55 (2H, br s, H-1 and H-2), 5.57 (1H, br d, H-5) [25].

MS : M^+ not observed, 295.1835 ($M-C_3H_7$, 1%; $C_{17}H_{27}O_4$ requires 295.1909), 277 (1), 236 (3), 221 (2), 218 (3), 193 (15), 175 (100) 25.

^{13}C NMR : the corresponding alcohol, Table 2 [25].

SOURCE : F. linkii Webb [25].

27. Linkiol



$C_{20}H_{34}O_4$
(Structure 27, R = angeloyl)

MP : 123-125° [26].
[α] : -17 [26].

IR : 3400, 1700, 1660, 1270, 1170 cm^{-1} [26].

MS : 338 (M^+), 320, 305, 277, 267, 265, 254, 238, 220, 212, 209, 194, 193, 167, 156 (100%), 151, 140, 136, 83 [26].

^{1}H NMR : 0.93 (3H, s), 0.95 (6H, t, J = 6 Hz), 1.24 (3H, s), 1.83 (3H, s), 5.00 (1H, q, J = 4 and 10 Hz), 4.10 (1H, q) [26].

SOURCE : F. linkii Webb [22,26].

28. p-Methoxybenzoate of linkitriol

$C_{23}H_{34}O_5$
(Structure 27, R = p-anisoyl)

IR : 3600, 3480, 2960, 2880, 1710, 1605, 1580, 1510, 1465, 1380, 1260, 1180, 1110, 1035, 950, 850 cm^{-1} [14].

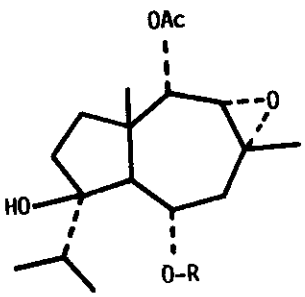
MS : 390 (M^+), 372, 319, 307, 277, 264, 238, 220, 212, 209, 207 [14].

^1H NMR : 0.95 (9H, apparent t), 1.31 (3H, s), 3.86 (3H, s, OMe), 5.15 (1H, d, J = 8 Hz, H-2), 6.93 and 8.10 (each 2H, d, J = 9 Hz) [14].

SOURCE : F. lancerottensis Parl.

29. 1-Acetate of lapiferol

(Structure 29, R = H).



MP : 106-108° [18].

IR : 3590, 2990, 2945, 2860, 1730, 1450, 1370, 1230, 1110, 1050, 970, 940 cm^{-1} [18].

MS : M^+ not observed, 269.1396 ($M-C_3H_7$, 1%; $C_{14}H_{21}O_5$ requires 269.1381), 251 (19), 209 (15), 191 (57), 173 (10), 163 (38), 149 (23), 139 (28) [18].

^1H NMR : 0.88 and 0.97 (each 3H, d, J = 4 Hz), 1.21 and 1.40 (each 3H, s), 2.10 (3H, s), 2.90 (1H, d, J = 6 Hz), 4.1 (1H, sx, J = 3 and 11 Hz), 4.92 (1H, d, J = 6 Hz) [18].

^{13}C NMR : Table 1 [18].

Acetate derivative [18].

SOURCE : F. linkii Webb [18].

30. 1-Acetate,5-isovalerate of lapiferol

(Structure 29, R = isovaleroyl)

MP : 115-116° [18].

IR ($CHCl_3$): 3600, 3000, 2950, 2860, 1730, 1720, 1460, 1455, 1380, 1365, 1290, 1230, 1180, 1110, 1045, 1030, 970, 940 cm^{-1} [18].

MS : M^+ not observed, 353.1963 ($M-C_3H_7$, 3%; $C_{19}H_{29}O_6$ requires 353.1964), 251 (37), 209 (25), 191 (93), 173 (13), 163 (48), 152 (31), 148 (26), 135 (16) [18].

^1H NMR : 0.83-1.01 (12H, complex signal), 1.28 and 1.45 (each 3H, s), 2.07 (3H, s), 2.36 (1H, d, J = 11 Hz), 2.97 and 4.96 (each 1H, d, J = 6 Hz), 5.16 (1H, sx, J = 3 and 11 Hz) [18].

^{13}C NMR : Table 1 [18].

SOURCE : F. linkii Webb [18].

31. Lapiferin

(Structure 29, R = angeloyl)

MP : 136-138° [18].

MP : 137-138° [27].

IR ($CHCl_3$): 3600, 3000, 2950, 2860, 1730, 1695, 1640, 1450, 1380, 1365, 1235, 1180, 1150, 1030, 955, 940, 890, 850 cm^{-1} [18].

MS : M^+ noot observed, 351.1963 ($M-C_3H_7$, 2%; $C_{19}H_{27}O_6$ requires 351.1964), 251 (18), 209 (9), 191 (38), 163 (23), 148 (17), 135 (12), 126 (23), 107 (15) [18].

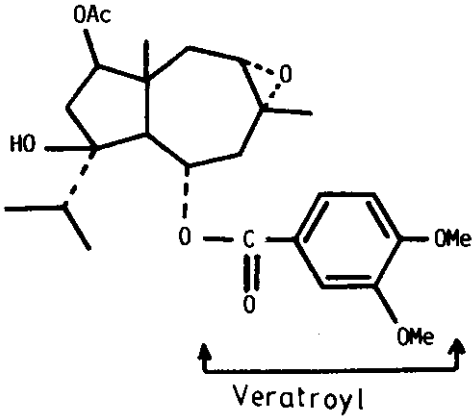
^1H NMR : 0.84 and 0.91 (each 3H, d, J = 3 Hz), 1.30 and 1.44 (each

3H, s), 2.34 (1H, d, J = 11 Hz), 2.82 and 4.88 (each 1H, d, J = 6 Hz), 5.21 (1H, sx, J = 3 and 11 Hz), 6.11 (1H) [18].

^{13}C NMR : Table 1 [18].

SOURCE : F. linkii Webb [18], F.lapidosa [27].

32. Lapiferinin

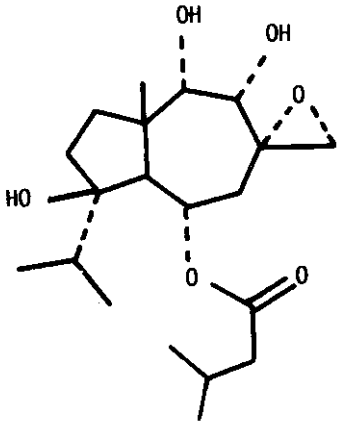


$C_{26}H_{38}O_8$

Lapiferinin has been isolated from F. lapidosa. UV, IR, MS and ^1H NMR were used to determine its structure.

Literature not available to the reviewer [28].

33. Isovalerate of epoxy-isolancerotetrol



IR($CHCl_3$): 3590, 3500, 3010, 3000, 2950, 2920, 2860, 1715, 1460, 1365, 1290, 1230, 1160, 1070, 970 cm^{-1} [22].

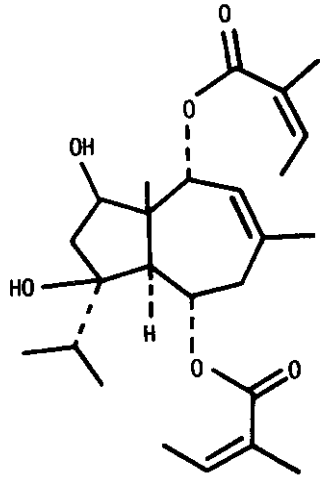
MS : M^+ not observed, 327.1819 ($M-C_3H_7$, 2%; $C_{17}H_{27}O_6$ requires 327.1808, 279 (2), 268 (1), 225 (33), 207 (23), 189 (35) [22].

^1H NMR : 0.87-0.94 (12H, complex signal), 1.17 (3H, s, H-14), 2.87 and 3.09 (each 1H,J=4 Hz, H-15), 3.75 and 3.97 (each 1H,d,J=3 Hz, H-1 and H-2), 5.40 (1H,J=6 and 11 Hz, H-5) [22].

^{13}C NMR : Table 2 [22].

SOURCE : F. linkii Webb [22].

34. Tingitanol



$C_{25}H_{38}O_6$

Amorphous

IR : 3470, 2960, 2920, 2860, 1700, 1680, 1450, 1380, 1345, 1260, 1230, 1150, 1115, 1075, 1030, 950, 840, 750 cm^{-1} [29].

MS : 434(M^+, 1%), 416(M-OH,2), 391 ($M-C_3H_7$,2), 334 (25), 317 (12), 291 (60), 216 (75), 120 (100), 83 (angeloyl, 85) [29].

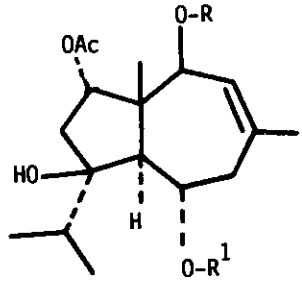
^{1}H NMR : 1.88 and 1.92 (each 3H,t,J=1 Hz), 2.03 (6H,tt,J=1 and 7 Hz), 6.12 (2H,br,q,J=7 and 10 Hz), 0.88 and 0.92 (each 3H,d,J=7 Hz), 1.14 (3H,s, H-14), 1.78 (3H,br s,H-15), 1.55 (1H,dd,J=10 and 12 Hz, H-9β), 2.2 (2H,m,H-9α and H-4β), 2.52 (1H,d, J=10 Hz,H-6), 2.72 (1H,brt,J=13Hz, H-4α), 3.58 (1H,dd,J=8 and 10 Hz, H-8), 5.07 (1H,d,J=8.0Hz,H-1), 5.35 (1H,dt,J=3, 10 and 12 Hz,H-5), 5.74 (1H,br d,J=8.0 Hz, H-2) [29].

^{13}C NMR : Table 3 [29].

X-ray : [29].

SOURCE : F. tingitana L. [29].

35.
$C_{25}H_{34}O_7$
(Structure 35,R=H; R^1= p-anisoyl)



MP : 152-154° [19].

UV($CHCl_3$): 1263 nm [19].

IR(KBr): 3460, 2965, 2930, 2875, 1703, 1672, 1603, 1580, 1510, 1468, 1440, 1420, 1380, 1275, 1170, 1128, 1100, 1033, 970, 932, 850, 830, 770, 700 cm^{-1} [19].

MS : 446(M^+,0.25%), 403 ($M-C_3H_7$, 14.5), 386 (M-AcOH,0.6), 343 (16.9), 251 ($M-C_3H_7$-p anisic acid, 14.3), 234 (M-AcOH-p anisic acid, 34.8), 216 (37.5), 201 (9.2), 191 ($M-C_3H_7$-AcOH, -p anisic acid, 68.7), 173 (48.3), 163 (44.5), 152 (p-anisic acid, 64.5), 148 (63.2), 135 (p-anisate 100), 120 (68.5), 105 (59.7), 92 (51), 77 (50.9), 71 (53), 43 (85.7) [19].

^{1}H NMR : 0.83 and 0.98 (each 3H,d, J=6.5 Hz,H-12 and H-13), 1.17 (3H, s, H-14), 1.84 (3H, br,s, H-15), 2.12 (3H,s,CH_3CO-), 2.22 (1H,dd,J=2.5 and 14.5 Hz,H-4β), 2.52 (1H,d,J=10.7 Hz,H-6), 3.88 (3H,s,OMe), 4.34 (1H,br s,H-1), 5.08 (1H,d,J=5.0 Hz, H-8), 5.28 (1H,dt,J=2.5, 10.7 and 11.2 Hz,H-5), 5.39 (1H,br s,H-2), 6.94 (2H,d,J=8.5Hz), 7.97 (2H,d, J=8.5Hz) [19].

SOURCE : F. communis subsp. communis [19].

36.
$C_{27}H_{36}O_8$
(Structure 35, R=Ac; R^1= p-anisoyl)
Gum

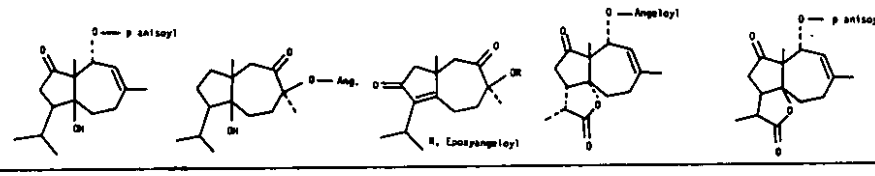
UV($CHCl_3$): 263 nm [19].

IR(KBr): 3450, 2970, 2880, 2850,1738, 1712, 1650, 1610, 1514, 1460, 1380, 1320, 1260, 1174, 1100, 1080, 1038, 970, 950, 852, 778 cm^{-1} [19].

MS : 488(M^+,0.5%), 471($M-H_2O$+H, 23.7), 445($M-C_3H_7$,14.7), 429 (M-AcOH+H,7.8), 411 (6.6), 385 (M-AcOH-C_3H_7,19.6), 368 (0.4), 337 (M-p-anisic acid + H,0.7), 325 (6.1), 319 (4.9), 293 (24.5), 277(M-p anisic acid -AcOH+H,30.8), 259 (35.2), 251 (17.3), 233(M-p anisic acid-AcOH C_3H_7,52.7), 217 (56.4), 201 (33.7), 199 (38.1), 191 (45.7), 173 (51.9), 152 (45.2), 135 (100), 119 (50.3), 43 (52.4) [19].

^{1}H NMR : Signal at δ 4.34 in the ^{1}H NMR spectrum of compound 35 is replaced by signal at δ 5.23 (H-1):

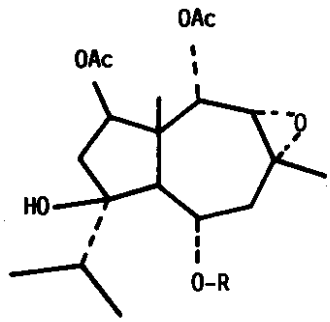
Table-4: ^{13}C-NMR data of Fercomin(41), 3-Angelate of felikiol (42), 3-Epoxy-angelate of webiol(49), Feruginin(50) and Fercolide(51).



Carbon No.	41	42	49	50	51
1	76.1 d	47.9	43.5	75.7 d	76.1 d
2	119.6 d	205.8	207.0	119.02d	119.0 d
3	146.6 d	85.1	87.4	146.7 s	147.2 s
4	29.1 t	37.4	40.3	37.48t	29.7 t
5	37.3 t	32.8	21.3	29.6 t	34.9 t
6	82.4 s	83.5	174.0	93.02s	93.1 s
7	60.2 s	47.2	41.4	59.08s	59.2 s
8	220.1 s	32.4	49.1	217.0 s	217.0 s
9	38.4 t	25.2	204.1	34.6 t	37.4 t
10	51.5 d	53.8	174.0	45.38d	50.9 d
11	26.2 d	27.4	25.5	38.29d	38.4 d
12	21.3 q	21.4	20.3	177.29s	177.4 s
13	24.9 q	22.9	20.7	11.02q	11.0 q
14	18.2 q	23.4	21.6	26.02q	18.6 q
15	26.4 q	24.3	30.1	18.57q	26.1 q
ester	165.0,163.6, 131.5,122.8, 113.8,55.5.			165.81,139.58, 126.56,20.63, 15.67.	164.7,163.7, 131.4,122.3, 114.0,55.5.

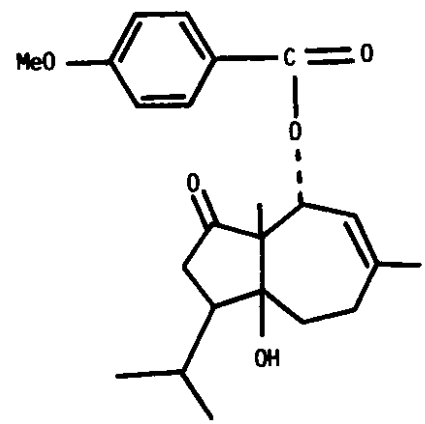
39. Lapidolin (R = angeloyl)

40. Lapidolinin (R = veratroyl)



Two compounds have been isolated from F. lapidosa. Spectroscopic methods were used to determine their structures. Literature not available to the reviewer [30].

41. Fercomin



$C_{23}H_{30}O_5$

MP : 130-132° [31].

UV : 261 nm [31].

IR(KBr): 3520, 3070, 2860, 1740 sh, 1730, 1710, 1608, 1580, 1512, 1320, 1275, 1260, 1170, 1100, 1030, 962, 840, 850, 772 cm^{-1} [31].

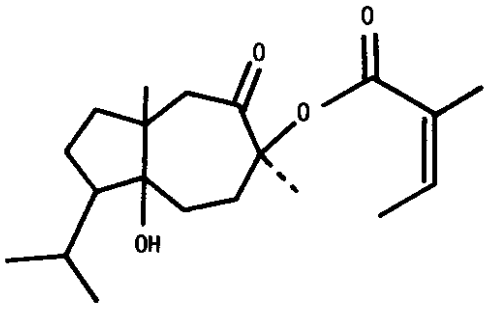
MS : 386(M^+,4%), 368 (10.8), 343 (6.8), 289 (16.5), 251 (86.3), 235 (49.5), 233 (53.2), 217 (39.2), 191 (55.7), 152 (56.5), 135 (100) [31].

^1H NMR : 1.02 and 1.14 (each 3H,d, J=6.5 Hz,H-12 and H-13), 1.1 (3H,s, H-14), 1.76 (3H,br s,H-15), 3.86 (3H,s,OMe), 5.46 (1H,d,J=9 Hz,H-1), 5.72 (1H,br d,J=9 Hz,H-2), 6.9 (2H,d,J=8.8 Hz), 7.88 (2H,d,J=8.8 Hz) [31].

^{13}C NMR : Table 4 [31].

SOURCE : F. communis subsp. communis [31].

42. 3-Angelate of felikiol



$C_{20}H_{32}O_4$

MP : 106-108° [25]

IR($CHCl_3$): 3590, 3000, 2940, 2860, 1700, 1450, 1360, 1140, 1040, 850 cm^{-1} [25]

MS : 366(M^+,1%), 277 (1), 253 (4), 236 (10), 218 (6), 193 (36), 175 (33) [25].

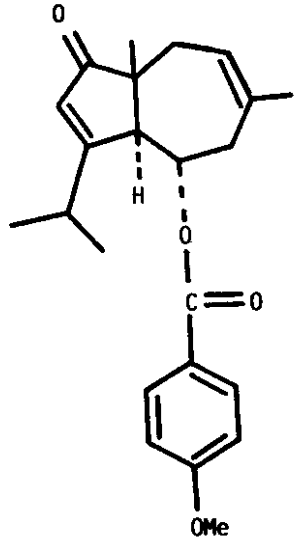
^1H NMR : 0.95 and 1.02 (each 3H,d, J=5 Hz,H-12 and H-13), 1.05 and 1.55 (each 3H,s,H-14 and H-15), 2.30 and 2.56 (each 1H,d,J=12 H,H-1), 6.15 (1H, Ang.) [25].

^{13}C NMR : Table 4 [25].

X-ray crystallography: [25].

SOURCE : F. linkii Webb [25].

43.
$C_{23}H_{28}O_4$



UV : 261, 314sh nm [19].

IR($CHCl_3$): 2990, 2940, 2895, 1720, 1710, 1660, 1610, 1585, 1518, 1260, 1175, 1120, 1100, 1040, 938, 853 [19].

MS : 368(M^+,1.7%), 340(M-CO, 1.75), 300(F, 5.9), 290 (8.3), 234(M-p anisate+H,2.9), 216(M-p anisic acid, 25.3), 201 (9.3), 191(M-C_3H_7-P anisate +H, 8.3), 173(M-p anisic acid-C_3H_7,20.9), 159 (9.2), 152(p anisic acid,11.5), 135(p-anisate, 100), 83 (60.5) [19].

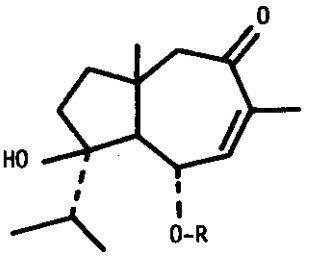
^1H NMR : 1.06 and 1.1 (each 3H,d, J=6.5 Hz,H-12 and H-13), 1.26 (3H,s,

H-14), 1.78 (3H,d,J=2Hz, H-15), 2.29 (1H,dd,J=4.6 and 15 Hz,H-4β), 2.57 (1H,septet,H-11), 2.92 (1H,br dd, J=4.6 and 15Hz, H-4α), 3.35 (1H, dd, J=2 and 10.5 Hz, H-6), 3.89 (3H, s,OMe), 5.59 (1H,ddd,J=3.2, 4.6 and 10.5 Hz,H-5), 5.59 (1H,br t,H-2), 5.89 (1H,q,J=1 and 2.1 Hz,H-9), 6.96 (2H,d,J=8Hz), 8.05 (2H,d,J=8 Hz) [19].

SOURCE : F. communis subsp. communis [19].

44. Lancerodiol

(Structure 44, R = H)



UV : 220 nm [14].

IR($CHCl_3$): 3480, 3010, 2965, 2880, 1660, 1610, 1470, 1450, 1380, 1240, 1175, 1050, 1000, 980, 855 cm^{-1} [14].

MS : 244.1610($M-H_2O$, requires 234.1600), 219, 209, 194, 191, 173, 165, 163 [14].

^1H NMR : 0.91 and 0.98 (each 3H,d, J=8 Hz,H-12 and H-13), 1.09 (3H,s, H-14), 1.87 (3H,br s,H-15), 2.14 (1H,d,J=11Hz,H-6), 2.55 and 2.80 (each 1H,d, J=8Hz, H-1), 4.62 (1H, d,J=11Hz,H-5), 6.35 (1H,br s,H-4) [14].

SOURCE : F. lancerottensis Parl [14].

45. p-Hydroxybenzoate of lancerodiol

$C_{22}H_{28}O_5$

(Structure 44, R = p-hydroxybenzoyl)

MR : 227-228° [14].

IR($CHCl_3$): 3590, 2970, 1700, 1670, 1610, 1595, 1520, 1460, 1390, 1330, 1270, 1170, 1100, 940, 850 cm^{-1} [14].

MS : 372(M^+), 329, 234, 219, 191, 163, 148 [14].

^1H NMR : 0.83 and 0.94 (each 3H,d, J=5 Hz), 1.23 (3H,s,H-14), 1.88 (3H, br s,H-15), 6.13 (1H,d,J=11 Hz,H-5), 6.21 (1H,br s,H-4), 6.92 and 8.00 (each 2H,d,J=9 Hz) [14].

SOURCES: F. lancerottensis Parl [14], F. linkii Webb [25].

46. p-Methoxybenzoate of lancerodiol

$C_{23}H_{30}O_5$

(Structure 44, R = p-methoxybenzoyl)
Gum

IR($CHCl_3$): 3540, 2990, 1720, 1670, 1610, 1520, 1470, 1395, 1180, 1105, 1040, 850 cm^{-1} [14].

MS : 386.2073(M^+; $C_{23}H_{30}O_5$ requires 386.2093), 359, 343, 325, 276, 251, 248, 234, 219, 216, 205, 201, 191 [14].

^1H NMR : 0.86 and 0.95 (each 3H,d, J=8 Hz), 1.28 (3H,s,H-14), 1.80 (3H, br s,H-15), 2.51 (1H,d,J=11 Hz,H-6), 2.70 (2H,br s,H-1), 3.90 (3H,s), 6.15 (1H,d,J=11 Hz,H-5), 6.20 (1H,br s,H-4), 6.98 and 8.05 (each 2H,d,J=9 Hz) [14].

SOURCE : F. lancerottensis Parl [14], F. linkii Webb [25].

47. Veratrate of lancerotol

$C_{24}H_{32}O_6$

(Structure 44, R = veratroyl)

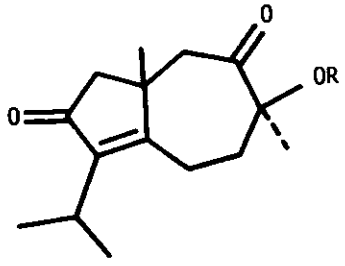
MS : 416.2233(M^+, $C_{24}H_{32}O_6$ requires 416.2199), 234 (10%), 216 (2), 191 (71), 182 (100), 165 (100) [25].

^{1}H NMR : 0.90 (6H,t,H-12 and H-13), 1.24 (3H,s,H-14), 1.88(3H, br s, H-15), 2.68(2H,s,H-1), 3.92, 3.94 (each 3H,s,2 X OMe), 6.22(2H,br d, H-4 H-5), 6.88 (1H,d,J=8Hz), 7.55 (1H,d,J=2Hz), 7.75 (1H,d,J=8Hz) [25].

SOURCE : F. linkii Webb [25].

48. 3-angelate of webiol

$C_{20}H_{28}O_4$



(Structure 48, R = angeloyl) Gum

IR($CHCl_3$): 3020, 3000, 2940, 2860, 1715, 1450, 1360, 1140, 1090, 990, 970 cm^{-1} [25].

MS : 332.1976(M^+, $C_{20}H_{28}O_4$ requires 332.1987), 290, 249, 232, 208 cm^{-1} [25].

^{1}H NMR : 1.11 and 1.19(each 3H,d,J=2 Hz,H-12 and H-13), 1.21 and 1.52(each 3H,s,H-14 and H-15), 6.23(1H,Ang.) [25].

SOURCE : F. linkii Webb [25].

49. 3-Epoxyangelate of webiol

(Structure 48, R = epoxyangeloyl)

MP : 82-84° [25].

IR($CHCl_3$): 3075,3000,2950,2920, 2860,1740,1715, 1690,1625,1600,1455, 1410,1370,1320,1270,1150,1100,995, 855 cm^{-1} [25].

UV : 242 nm [25].

MS : 348(M^+), 333,320,232,207,189, 149,121 [25].

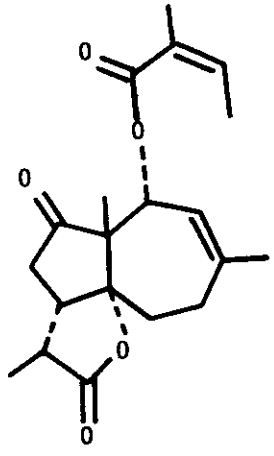
^{1}H NMR : 1.08 and 1.12(each 3H,d, J=5Hz,H-12 and H-13), 1.17(3H,s,H-14), 1.36(3H,d,J=5Hz), 1.44(3H,s), 1.64(3H,s,H-15), 3.09(1H,J=5Hz) [25].

^{13}C NMR : Table 4 [25].

SOURCE : F. linkii Webb [25].

50. Feruginin

$C_{20}H_{26}O_5$



MP : 90° [16].

$[\alpha]_D^{35}$: -46.6°($CHCl_3$; c 0.6) [16].

UV : 216 nm [16].

IR(KBr): 2900-2860, 1780, 1755, 1725, 1660, 1460, 1380, 1170, 1050, 985, 900, 825 cm^{-1} [16].

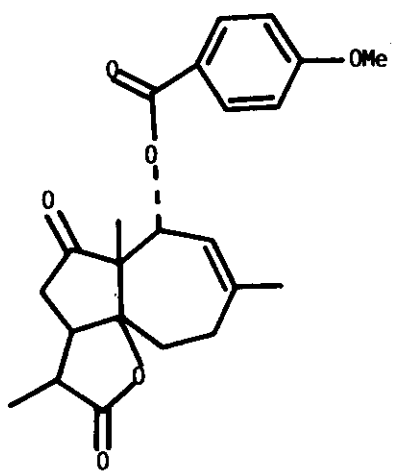
MS : 346.178(M^+, 2%), 331(10.2), 318 (346-CO, 0.3), 284(1.5), 264(10), 263 (346-C_5H_7O,36), 247(346-OAng.,16), 246(346-Angelic acid,7), 219(247-CO,3), 201(5), 191(5), 173(12), 163(4), 145(5), 135(5), 119(6), 107(6), 84(7), 83(MeCH=C(Me)C=O, 100), 82(7), 74(10), 59(20), 55(83-Co, 80) [16].

^{1}H-NMR : 1.16(3H,s,H-14), 1.26 (3H,d,J=7 Hz,13), 1.77 (3H,br s, H-15), 1.82 (3H,dq,J=1.5 Hz), 1.97 (3H,dq,J=1.5 and 7 Hz), 2.12 (2H,m, H-5), 2.24 and 2.45 (each 1H,dd,J=9 and 18Hz, 2H-9), 2.57-2.7 (2H,m, 2H-4), 2.91 (1H,ddd, J=7 and 11.9 Hz,H-10), 3.12 (1H,dq,H-11), 5.28 (1H,d,J=7.5 Hz,H-1), 5.71 (1H,br dq, J=7.5 Hz,H-2), 6.06 (1H,qq,J=1.5 and 7 Hz) [16].

^{13}C-NMR : Table 4 [16].

SOURCE : F. jaeschkeana Vatke [16].

51. Fercolide Amorphous mass



UV : 261 nm [31].

IR(KBr): 3062, 2930, 1775, 1746, 1710, 1608, 1510, 1260, 1170, 1100, 1080, 980, 940, 850, 772 cm^{-1} [31].

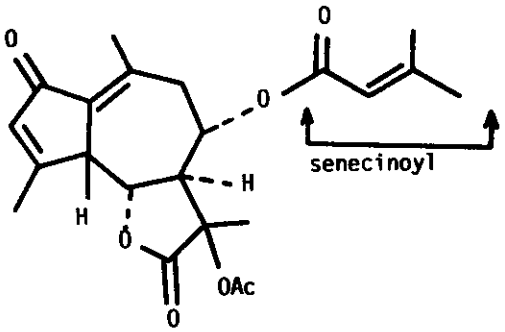
MS : 398(M^+, 12.7%), 316(8), 263(83), 246(52.5), 219(39.9), 173(56.2), 152 (68.5), 135(100) [31].

^{1}H-NMR : 1.28 (3H,d,J=7Hz,H-13), 1.22(3H,s,H-14), 1.78(3H,br s,H-15), 2.26(1H,dd,J=10.5 and 19Hz,H-3β), 2.48(1H,dd,J=8.6 and 19 Hz,H-3α), 3.03(1H,ddd,J=7.4, 8.6 and 10.5 Hz, H-10), 3.21(1H,ddd,J=7 and 7.4Hz, H-11), 3.88(3H,s,OMe), 5.48(1H,d, J=8.2 Hz,H-1), 5.76(1H,br d,J=8.2 Hz,H-2), 6.94 and 7.85 (each 2H,d, J=8.8Hz) [31].

^{13}C-NMR : Table 4 [31].

SOURCE : F. communis subsp. communis [31].

52. Ferolide



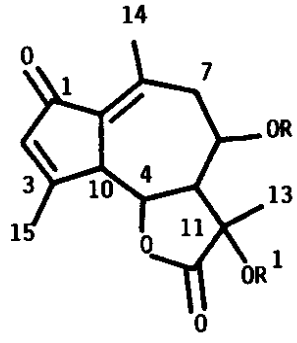
$C_{22}H_{26}O_7$

MP : 178-179° [32].

original literature not available to the reviewer [32].

SOURCE : F. penninervis.

53. Malaphyllinin



$C_{24}H_{24}O_7$
(Structure 53, R=benzoyl; R^1=Ac)

MP : 231-235° (ethanol) [33].

[α] : + 19° ($CHCl_3$; c, 1.156) [33].

UV : 202, 238, 251 sh nm [33].

IR : 1795, 1745, 1714, 1695, 1645, 1625, 1610 [33].

MS : 424(M^+), 382, 364, 302, 260, 242, 105, 43 [33].

^{1}H-NMR : 1.62(3H,s,CH_3-13), 2.15 (3H,s), 2.25(6H,s,CH_3-14 and CH_3-15), 2.59(1H,q,H-7β), 3.04(1H, q,H-7α), 3.65(1H,q,H-10), 3.72(1H, q,H-5), 4.73(1H,q,H-4), 5.76(1H, sx,H-6), 6.22(1H,H-2), 7.60(1H,t, H-4), 7.48(2H,t,H-3 and H-5), 8.05 (2H,m,H-2 and H-6) [33].

SOURCES: F. gigantea B.Fedtch [33], F. malacophylla [34].

54. Gigantolide

$C_{25}H_{26}O_8$
(Structure 53, R=p-anisoyl; R^1= Ac).

MP : 192-193° [33].

[α] : +2.1($CHCl_3$;c,0.804) [33].

UV : 202, 211, 261 nm [33].

IR : 1789, 1745, 1708, 1689, 1640, 1620, 1610 cm^{-1} [33].

MS : 454(M^+), 412, 394, 302, 260, 242, 152, 135, 43 [33].

^{1}H-NMR : 1.58(3H,s,CH_3-13), 2.14 (3H,s), 2.25(6H,CH_3-14 and CH_3-15), 2.56(1H,q,H-7β), 3.04(1H,q,H-7α), 3.61(1H,d,H-10), 3.68(1H,q,H-5), 3.88(3H,s,OMe), 4.72(1H,q,H-4), 5.72(1H,sx,H-6), 6.22(1H,H-2), 6.96 (2H,m), 7.99(2H,m) [33].

SOURCE : F. gigantea B. Fedtch [33].

55. Talassin

$C_{25}H_{30}O_7$
(Structure 53, R=R^1= angeloyl)

MP : 188-191° [33].

[α] : -2.3° ($CHCl_3$;c,0.278) [33].

UV : 202, 224, 252 nm [33].

IR(Nujol): 1795, 1710, 1692, 1640 cm^{-1} [33].

MS : 442(M^+), 382, 364, 342, 105, 83 [33].

^{1}H-NMR : 1.86(6H,s), 1.99(6H,d), 6.22(2H,m), remaining signals are similar to those of compound 54 [33].

SOURCES: F. gigantea B. Fedtch [33], F. litvinowiana [35], F. malacophylla [36].

56. Malaphyllin

$C_{26}H_{28}O_9$
(Structure 53, R=veratroyl; R^1=Ac).

MP : 216-218° [33].

[α] : + 3.1($CHCl_3$;c,0.855) [33].

UV : 203, 223, 264, 296 nm [33].

IR : 1790, 1745, 1710, 1692, 1641, 1621, 1605 [33].

MS : 484(M^+), 442, 424, 302, 260, 242, 182, 165, 43 [33].

^{1}H-NMR : 3.90 and 3.92 (each 3H,s, 2 x OMe), 6.9 (1H,d,J=8.0Hz), 7.53 (1H,d,J=8.0Hz), 7.65 (1H,q,J=2.5 and 8.0Hz), other signals are similar to those of compound 54 [33].

SOURCE : F.gigantea B. Fedtch [33], F.litvinowiana [35], F. malacophylla [36].

57. Giferolide

$C_{27}H_{28}O_7$

(Structure 53,R=benzoyl;R^1=senecinoyl)

MP : 263-266° (decomp.) [33].

[α] : -5.9($CHCl_3$;c,0.689) [33].

UV : 202, 231, 254 sh nm [33].

IR : 1790, 1710, 1691, 1642, 1621, 1605 cm^{-1} [33].

MS : 464(M^+), 382, 364, 342, 260, 242, 105, 83 [33].

^{1}H-NMR : 1.20 and 1.97 (each 3H,s), 5.78 (1H,s), 7.4 (1H,t), 8.09 (2H,m), 8.57 (2H,m); other signals are similar to those of compound 54 [33].

SOURCE : F. gigantea B. Fedtch [33].

58. Ferugolide

$C_{28}H_{30}O_8$

(Structure 53,R=p-anisoyl;R^1=senecinoyl)

MP : 232-234° [33].

UV : 203, 210-214, 216, 232 nm [33].

IR : 1791, 1720, 1697, 1645, 1625, 1610 cm^{-1} [33].

MS : 494(M^+), 412, 394, 342, 260, 242, 152, 135, 83 [33].

^{1}H-NMR : 2.00(3H,s), 2.20(3H,s), 5.81(1H,s), 3.91(3H,s), 6.99(2H,m), 8.04(2H,m); remaining signals are similar to those of compound 54 [33].

SOURCE : F. gigantea B. Fedtch [33].

59. Malaphyll

$C_{29}H_{32}O_9$

(Structure 53,R=veratroyl;R^1=senecinoyl)

MP : 212-213° [33].

[α] : -5.6°($CHCl_3$;c,0.958) [33].

UV : 205, 223, 262, 295 nm [33].

IR : 1789, 1720, 1710, 1690, 1640, 1620, 1604 cm^{-1} [33].

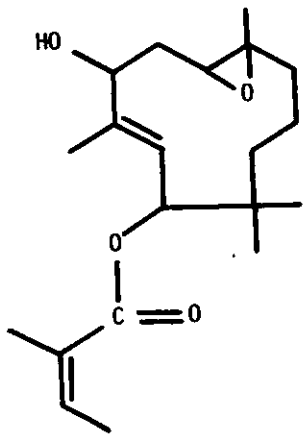
MS : 524(M^+), 442, 424, 342, 260, 242, 182, 165, 83 [33].

^{1}H-NMR : 1.90(3H,s), 2.12(3H,s), 5.75(1H,s), 3.97 and 3.92(each 3H,s), 6.92(1H,d,J=8Hz), 7.54(1H,d,

J=2.5Hz), 7.72(1H,q,J=2.5 and 8.0Hz); other signals are similar to those of compound 54 [33].

SOURCES: F.gigantea B.Fedth [33], F.litvinowiana [35], F. malacophylla [36].

60. Chatferin



Its structure was established by spectroscopic methods [37].

Literature not available to the reviewer [37].

Botanical Sources of Sesquiterpenoids

Ferula communis subsp. communis

Jaeschkeanadiol	1
Ferutinin	4
Ferutidin	5
Compound 8	8
Compounds 16-20 Ref.19	16-20
Compounds 22-23 Ref.19	22,23
Compounds 35-38 Ref.19	35-38
Fercomin	41
Compound 43 Ref.19	43
Fercolide	51

Ferula elaeochytris

Angeloyl of jaeschkeanadiol	2
Teferidine	3
Ferutinin	4
Ferutidin	5
5-Salicylate of jaeschkeanadiol	6
Teferin	7

Ferula gigantea B. Fedtch

Malaphyllinin	53
Gigantolide	54
Talassin	55
Malaphyllin	56
Giferolide	57
Ferugolide	58
Malaphyll	59

Ferula jaeschkeana Vatke

Jaeschkeanadiol	1
Ferutinin	4
Teferin	7
Jaeschferin	21
Feruginin	50

Ferula kuhistanica

Ferutidin	5

Ferula lancerottensis Parl

Ferutinin	4
p-Hydroxybenzoate of epoxyjaeschkeana-diol	10
p-Hydroxybenzoate of lancerotriol	13
p-Methoxybenzoate of linkitriol	28
lancerodiol	44
p-Hydroxybenzoate of lancerodiol	45
p-methoxybenzoate of lancerodiol	46

Ferula lapidosa

Lapiferin	31
Lapiferinin	32
Lapidolin	39
Lapidolinin	40

Ferula linkii Webb

Jaeschkeanadiol	1
Ferutidin	5
Isovalerate of epoxyjaeschkeanadiol	9
p-Methoxybenzoate of epoxyjaeschkeana-diol	11

Veratrate of epoxyjaeschkeanadiol	12
5-Isovalerate of isolancerotriol	14
1-Acetate-5-isovalerate of ferulinkiol	15
5-Isovalerate of isolancerotetrol	24
5-Angelate of isolancerotetrol	25
5-Isovalerate of ferutriol	26
Linkiol	27
1-Acetate of lapiferol	29
1-Acetate-5-isovalerate of lapiferol	30
Lapiferin	31
Isovalerate of epoxyisolancerotetrol	33
3-Angelate of felikiol	42
Veratrate of lancerotol	47
3-Angelate of webiol	48
3-Epoxyangelate of webiol	49
Ferula litvinowana	
Talassin	55
Malaphyllin	56
Malaphyll	59
Ferula malacophylla	
Malaphyllinin	53
Talassin	55
Malaphyllin	56
Malaphyll	59
Ferula Ovina	
Ferutinin	4
Ferula penninervis	
Ferolide	52
Ferula sinaica	
Jaeschkeanadiol	1
Ferutidin	5
Compound 36	36
Ferula tenuisecta	
Teferidine	3
Teferin	7
Ferula tingitanol L.	
Tingitanol	34
Ferula tschatcalensis	
Chatferin	60

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