Chemical constituents of *Cephalotaxus* species

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The compounds isolated from *Cephalotaxus* species during the period 1930 to March 2002 have been reviewed; these have been listed showing their source(s).

Introduction

Cephalotaxus was once regarded as a genus of the family Taxaceae on the basis of morphology, anatomy, embryology and geographical distribution. But based upon the recent findings of chemical constituents of different species of this genus, the classification of the genus *Cephalotaxus* to a separate family, the Cephalotaxaceae of the order Coniferae has been supported^{1,2}. *Cephalotaxus*, the only genus of this family consists of mainly eleven species, namely, *C. drupacea* (now known as *C. harringtonia* var. *drupacea*), *C. follicularis*, *C. fortunei* Hook. f., *C. griffithii* Hook., f., *C. hainanensis* Linn., *C. harringtonia* (forbes) Koch., *C. lanceolata*, *C. mannii* Hook. f., *C. oliveri* Mast., *C. sinensis* Li. - and *C. wilsoniana*.

Cephalotaxus is native to Eastern Asia and plants of this genus are evergreen coniferous trees with yew like leaves or shrubs that grow in humid valleys or in forests at an elevation of 100–2000 m. *Cephalotaxus* species, commonly known as plum yew, are generally hard and ornamental, and succeed on a variety of soils; they can be propagated from seeds and cuttings. The plum yews can be grown as hedges and excellent screens. The three species, namely, *C. griffithii* Hook. f., *C. harringtonia* (or *C. drupacea*) and *C. mannii* Hook. f. occur in India, *C. harringtonia* also occurs in Japan and the remaining eight species along with *C. mannii* are indigenous to China^{3,4}. *Cephalotaxus* species have also been reported to be used as traditional medicine, e.g. Shanjishan, a traditional Chinese medicine derived from bark and leafy branches of *C. fortunei* Hook f., is used as immunosuppressant and antineoplastic agent⁵.

Cephalotaxus species, in general, are mainly known for alkaloids; different alkaloids isolated from *Cephalotaxus* species have been reviewed earlier¹. Several flavones, biflavones, taxanes, sterols, etc. have also been isolated

from different *Cephalotaxus* species. In this review, we give an update and comprehensive compilation of different classes of compounds isolated from various species of *Cephalotaxus*, alongwith their biological activities. Various compounds isolated from eleven different *Cephalotaxus* species have been classified under the classes of alkaloids, biflavones, flavones, sterols and miscellaneous compounds and are listed in Tables 1–5.

Alkaloids

Wall *et al.*⁶ reported in 1954 the first phytochemical examination of the genus *Cephalotaxus* and showed the

1 R=CH₃CO

3 R=

14 R=H

55 R=

4 R₁=R₂=R₃=H, n=4

21 R₁=R₂=R₃=H, n=2

39 R₁=R₂=H, R₃=OH, n=2

40 R₁=R₂=R₃=H, n=3

41 R₁=R₂=H, R₃=OH, n=3

45 R₁=R₂=H, R₃=β-OH, n=2

47 R₁=R₂=H, R₃=α-OH, n=3

48 R₁=R₂=H, R₃=β-OH, n=3

52 R₁=OH, R₂=R₃=H, n=2

56 R₁=R₂=R₃=H, n=1

Scheme 1. Biosynthetic route suggested for the derivation of the cephalotaxine series of alkaloids.

presence of alkaloids in this genus. Paudler *et al.*⁷ isolated cephalotaxine (14), a crystalline alkaloid from *C. harringtonia* var. *drupacea* and *C. fortunei*. Two types of alkaloids, namely, cephalotaxine and homoerythrina

the exception in *C. wilsoniana*⁸. The occurrence of cephalotaxus and homoerythrina alkaloids in the same plant suggests that they may be formed through similar biogenetic routes (Scheme 1)⁹.

alkaloids based upon the skeletons I and II, respectively, are found in the genus *Cephalotaxus*. The homoerythrina alkaloids are present as minor alkaloids in this genus with

Cephalotaxine (14) accounts for nearly 50% of the total alkaloids present in *Cephalotaxus* plant extracts but it is inactive. Three antitumour alkaloids, all esters of cephalotaxine (14), i.e. harringtonine (39), homoharringtonine (41) and isoharringtonine (52), isolated from *C. harringtonia* have shown significant inhibitory activity against experimental lymphoid leukemia systems L1210 and P388 in mice¹⁰. Zhang *et al.*¹¹ reported the inhibitory activity of harringtonine (39) against sarcoma 180 in mice and against nonlymphoblastic leukemia in clinical experiments. In clinical tests, harringtonine (39) appeared to be effective in treating acute and chronic myelocytic leukemia in human subjects¹². Harringtonine (39) and homoharringtonine (41) had significant activities against P388 leukemia, L1210 leukemia and B16 melanoma. The therapeutic indexes (LD₅₀ and ED₅₀) in B16 melanoma system¹³ were 1.90 and 2.31. The alkaloids isolated from *C. fortunei* were used for the treatment of lymphosarcoma, Hodgkin's disease, reticular cell sarcoma, lung cancer and for various kinds of leukemia and malignant tumors. The total alkaloids of *C. sinensis* and *C. hainanensis* showed

good effects in chronic granulocytic leukemia, chorionepithelioma, cancer of thymus, lymphosarcoma and Hodgkin's disease⁵.

Mikolajczak *et al.*¹⁴ isolated the alkaloid deoxyharringtonine (21) with significant antileukemic activity from *C. harringtonia*. It showed the antileukemic activity of the same order of magnitude as that previously reported for the other three cephalotaxine esters 39, 41 and 52. Hainanensine (38), an antitumour alkaloid from *C. hainanensis*, inhibited the growth of P388 tumour cells¹⁵.

Alkaloid G (2) and drupacine (26) are identical and showed most of the same major peaks with only minor differences in some of the reported chemical shifts. However, there are considerable differences in the melting points of alkaloid G⁸ (131.0–131.5°) and drupacine (70–72°)¹⁶. Alkaloids possessing the homoerythrina ring system are known to occur in *Schelhammera* species^{17,18} but from the

16 $R_1, R_2 = -OCH_2O-$; $R_3 = OCH_3$, $R_4 = H$
 17 $R_1, R_2 = -OCH_2O-$; $R_3 = H$, $R_4 = OCH_3$
 33 $R_1 = R_2 = OCH_3$; $R_3 = OCH_3$; $R_4 = H$
 59 $R_1 = R_2 = OCH_3$; $R_3 = H$, $R_4 = OCH_3$

Cephalotaxus genus, for the first time, five homoerythrina alkaloids (30, 31, 37, 53 and 57) were isolated from *C. harringtonia*⁹. They were the simple derivatives of schelhammericine. Later on several homoerythrina alkaloids were isolated from *C. wilsoniana* and *C. fortunei*. Comosimine (16) isolated from *C. fortunei*¹⁹, *epi*-phelline from *C. sinensis*²⁰ and alkaloid-6 from *Phelline comosa*²¹ have the same structure. A new alkaloid drupangtonine (27) isolated from *C. harringtonia* showed antileukemic activity against P388 leukemia cells²². New cephalotaxus alkaloids bishomo-

deoxyharringtonine (4), homodeoxyharringtonine (40) and nordeoxyharringtonine (56) isolated from *C. harringtonia* (var. *drupacea*) have shown antileukemic activity against P388 leukemia cells²³. These compounds are less cytotoxic than deoxyharringtonine (21). A dimeric ester alkaloid cephalotaxidine (12) has also been isolated from *C. harringtonia*²⁴, and this is the first example of the dimeric *Cephalotaxus* alkaloid. Qiu *et al.*²⁵, isolated a novel alkaloid fortunine (37) along with 11-hydroxycephalotaxine (44) and wilsonine (59) from *C. fortunei*. Alkaloids 42, 45, 47–49 and 55 showed antileukemic activities against P388 leukemia cells and their IC₅₀ values were 0.28, 0.38, 0.33, 0.17, 0.19, and 0.012 µg/ml, respectively^{26,27}. Recently, Morita *et al.*²⁸ isolated potent cytotoxic alkaloids cephalozomines A–F 5–10 from *C. harringtonia* var. *nana* along with several known alkaloids like drupacine (26), desmethylcephalotaxine (23), cephalotaxine (14), 11-hydroxycephalotaxine (44), *epi*-schelhammericine B (32), 3-*epi*-schelhammericine (31), harringtonine (39), homodeoxyharringtonine (40), deoxyharringtonine (21) and isoharringtonine (52).

Several synthetic routes have been developed towards the synthesis of cephalotaxine (14)^{29–34} and its derivatives, e.g. deoxyharringtonine (21), harringtonine (39), homohar-

ringtonine (41) and isoharringtonine (52)³⁵⁻³⁸. Various alkaloids isolated from *Cephalotaxus* species are listed in Table 1.

Table 1. Alkaloids from *Cephalotaxus* species

Isolated compd.	Species	Ref.
Acetylcephalotaxine (1)	<i>C. fortunei</i> <i>C. hainanensis</i> <i>C. wilsoniana</i>	1, 39, 40, 41, 42, 43, 44 1, 45, 46 1, 8, 47
Alkaloid G (2)	<i>C. wilsoniana</i>	8, 47
Anhydroharringtonine (3)	<i>C. fortunei</i>	44
Bishomodeoxyharringtonine (4)	<i>C. harringtonia</i> (var. <i>drupacea</i>)	23
Cephalezomines A-F (5-10)	<i>C. harringtonia</i> (var. <i>nana</i>)	28
Cephalofortuneine (11)	<i>C. fortunei</i>	1, 19, 48
Cephalotaxidine (12)	<i>C. harringtonia</i> (var. <i>drupacea</i>)	24
Cephalotaxinamide (13)	<i>C. hainanensis</i>	1, 45, 46
Cephalotaxine (14)	<i>C. fortunei</i> <i>C. griffithii</i> <i>C. hainanensis</i> <i>C. harringtonia</i> (var. <i>drupacea</i>) <i>C. harringtonia</i> (var. <i>harringtonia</i>) <i>C. harringtonia</i> (var. <i>nana</i>) <i>C. oliveri</i> <i>C. sinensis</i> <i>C. wilsoniana</i>	1, 7, 40, 41, 42, 44, 49, 50 49 1, 12, 45, 46 7, 10, 51, 52 1, 8, 9, 49, 53, 54, 55 28 1, 11 1, 20, 56, 57 1, 8, 47, 49
Cephalotaxinone (15)	<i>C. fortunei</i>	1, 40, 41, 53, 54

Comosimine (16)
(*epi*-phelline, alkaloid-6)
Cycloxyisoschelhammericine (17)

Demethylcephalotaxine (18)

Demethylnedrupacine (19)
7-Deoxycephalofortuneine (20)
Deoxyharringtonine (21)

Deoxyharringtonic acid (22)
Desmethylcephalotaxinone (23)

5'-Des-O-methylharringtonine (24)

5'-Des-O-methylhomo-
harringtonine (25)
Drupacine (26)

Drupangtonine (27)

epi-Cephalotaxine (28)

3-*epi*-Fortuneine (29)
epi-Methylschelhammericine B (30)

3-*epi*-Schelhammericine (31)

epi-Schelhammericine B (32)

3-*epi*-Wilsonine (33)

2-O-Ethylcephalofortuneine (34)
2-O-Ethylepicephalofortuneine (35)
Fortuneine (36)

<i>C. hainanensis</i>	1, 45
<i>C. harringtonia</i> (var. <i>harringtonia</i>)	1, 9, 55, 58
<i>C. fortunei</i>	19
<i>C. sinensis</i>	20
<i>C. hainanensis</i>	1, 45
<i>C. sinensis</i>	1, 20
<i>C. drupacea</i>	1, 51
<i>C. fortunei</i>	1, 40, 41
<i>C. hainanensis</i>	1, 45, 46
<i>C. fortunei</i>	19
<i>C. drupacea</i>	23, 26, 27, 49, 52, 59
(<i>C. harringtonia</i> var. <i>drupacea</i>)	
<i>C. fortunei</i>	44
<i>C. griffithii</i>	49, 55, 59
<i>C. hainanensis</i>	1, 12, 45, 55, 59
<i>C. harringtonia</i> (var. <i>harringtonia</i>)	1, 9, 14, 43, 49, 53
<i>C. harringtonia</i>	55, 58, 59, 60
(var. <i>nana</i>)	28
<i>C. hainanensis</i>	1, 45, 46, 59, 61
<i>C. fortunei</i>	42
<i>C. hainanensis</i>	1, 12, 45
<i>C. harringtonia</i> (var. <i>harringtonia</i>)	55
<i>C. harringtonia</i> (var. <i>nana</i>)	28
<i>C. sinensis</i>	1, 20, 56
<i>C. harringtonia</i> (var. <i>drupacea</i>)	52
<i>C. harringtonia</i> (var. <i>drupacea</i>)	52
<i>C. drupacea</i>	16, 49, 51
<i>C. fortunei</i>	1, 49, 50
<i>C. griffithii</i>	49
<i>C. hainanensis</i>	1, 22
<i>C. harringtonia</i>	28
<i>C. sinensis</i>	1, 20, 56
<i>C. wilsoniana</i>	1, 47
<i>C. harringtonia</i> (var. <i>drupacea</i>)	22
<i>C. fortunei</i>	1, 40, 41, 53, 54
<i>C. hainanensis</i>	1, 12
<i>C. fortunei</i>	19
<i>C. drupacea</i>	1
<i>C. fortunei</i>	53, 54
<i>C. harringtonia</i> (var. <i>harringtonia</i>)	9
<i>C. wilsoniana</i>	47
<i>C. drupacea</i>	1, 51
<i>C. fortunei</i>	54, 62
<i>C. hainanensis</i>	1, 12, 45
<i>C. harringtonia</i> (var. <i>harringtonia</i>)	1, 9
<i>C. harringtonia</i> (var. <i>nana</i>)	28
<i>C. wilsoniana</i>	1, 47
<i>C. drupacea</i>	1, 51
<i>C. hainanensis</i>	1
<i>C. harringtonia</i> (var. <i>harringtonia</i>)	1, 9
<i>C. harringtonia</i> (var. <i>nana</i>)	28
<i>C. fortunei</i>	1, 19, 44, 48, 62, 63
<i>C. griffithii</i>	49
<i>C. sinensis</i>	1, 56
<i>C. wilsoniana</i>	8, 47
<i>C. fortunei</i>	62
<i>C. fortunei</i>	62
<i>C. fortunei</i>	63

Table-1 (contd.)

Fortuneine (37)	<i>C. fortunei</i>	25
Hainanensine (38)	<i>C. fortunei</i>	15
	<i>C. hainanensis</i>	1, 15, 45
Harringtonine (39)	<i>C. drupacea</i>	10, 27, 49, 52, 59
	<i>C. fortunei</i>	41, 42, 44, 50, 59, 64, 65, 66
	<i>C. griffithii</i>	49, 59
	<i>C. hainanensis</i>	1, 12, 45, 59
	<i>C. harringtonia</i>	1, 9, 43, 53, 59, 60, 61, 67, 68
	(var. <i>harringtonia</i>)	67, 68
	<i>C. harringtonia</i>	28
	(var. <i>nana</i>)	
	<i>C. oliveri</i>	1, 11, 59
	<i>C. sinensis</i>	1, 56, 65
	<i>C. wilsoniana</i>	49, 59
Homodeoxyharringtonine (40)	<i>C. harringtonia</i>	23
	(var. <i>drupacea</i>)	
	<i>C. harringtonia</i>	60
	(var. <i>harringtonia</i>)	
	<i>C. harringtonia</i>	28
	(var. <i>nana</i>)	
Homoharringtonine (41)	<i>C. drupacea</i>	1, 27, 49, 51, 52, 59, 69
	<i>C. fortunei</i>	1, 41, 42, 44, 49, 50, 64, 65, 66, 69
	<i>C. griffithii</i>	49, 59, 69
	<i>C. hainanensis</i>	1, 12, 45, 59, 69
	<i>C. harringtonia</i>	1, 9, 43, 49, 53, 59, 60, 68, 69, 70
	(var. <i>harringtonia</i>)	
	<i>C. sinensis</i>	1, 20, 56, 59, 65, 69
	<i>C. wilsoniana</i>	49, 59, 69
Homoneoharringtonine (42)	<i>C. harringtonia</i>	27
	(var. <i>drupacea</i>)	
4-Hydroxycephalotaxine (43)	<i>C. fortunei</i>	71
11-Hydroxycephalotaxine (44)	<i>C. drupacea</i>	16, 49
	<i>C. fortunei</i>	1, 25, 48, 49, 50
	<i>C. griffithii</i>	1, 49
	<i>C. harringtonia</i>	49
	(var. <i>harringtonia</i>)	
	<i>C. harringtonia</i>	28
	(var. <i>nana</i>)	
	<i>C. sinensis</i>	1, 20, 56
	<i>C. wilsoniana</i>	49
11β-Hydroxydeoxyharringtonine (45)	<i>C. harringtonia</i>	26
	(var. <i>drupacea</i>)	
3'S-Hydroxy-5'-des-O-methyl-harringtonine (46)	<i>C. harringtonia</i>	52
	(var. <i>drupacea</i>)	
11α-Hydroxyhomodeoxyharringtonine (47)	<i>C. harringtonia</i>	26
	(var. <i>drupacea</i>)	
11β-Hydroxyhomodeoxyharringtonine (48)	<i>C. harringtonia</i>	26
	(var. <i>drupacea</i>)	
3'S-Hydroxyneoharringtonine (49)	<i>C. harringtonia</i>	27
	(var. <i>drupacea</i>)	
Isocephalotaxinone (50)	<i>C. fortunei</i>	44, 54
Isoharringtonic acid (51)	<i>C. hainanensis</i>	1, 45, 46
	<i>C. harringtonia</i>	52
Isoharringtonine (52)	<i>C. drupacea</i>	1, 27, 49, 51, 52, 59
	<i>C. fortunei</i>	1, 44, 59, 64
	<i>C. griffithii</i>	49, 59
	<i>C. hainanensis</i>	1, 12, 45, 59
	<i>C. harringtonia</i>	9, 43, 53, 59, 60, 61, 67, 68
	(var. <i>harringtonia</i>)	
	<i>C. harringtonia</i>	28
	(var. <i>nana</i>)	
	<i>C. sinensis</i>	1, 20, 59
	<i>C. wilsoniana</i>	1, 47, 49, 59
Methylschelhammericine B (53)	<i>C. harringtonia</i>	1, 9
	(var. <i>harringtonia</i>)	
Methyltaxodine (54)	<i>C. fortunei</i>	62
Neoharringtonine (55)	<i>C. fortunei</i>	44
	<i>C. harringtonia</i>	27
	(var. <i>drupacea</i>)	
Nordeoxyharringtonine (56)	<i>C. harringtonia</i>	23

Table-1 (contd.)

	(var. <i>drupacea</i>)	
Schelhammericine B (57)	<i>C. harringtonia</i>	1, 9
	(var. <i>harringtonia</i>)	
	<i>C. oliveri</i>	11
Taxodine (58)	<i>C. fortunei</i>	62
Wilsonine (59)	<i>C. fortunei</i>	25, 39, 63
	<i>C. griffithii</i>	49
	<i>C. sinensis</i>	1, 20, 56
	<i>C. wilsoniana</i>	1, 8

Biflavones

Only amentoflavone (60) and its methylated derivatives have been isolated from *Cephalotaxus* species (Table 2). The occurrence of highly methylated derivatives of amen-

toflavone, i.e. tetra-*O*-methylamentoflavone (61) was first reported by Ishratullah *et al.*⁷² from *C. harringtonia*. 6-*C*-Methyl-7-*O*-methylamentoflavone (65) isolated from *C. harringtonia* was the first example of a naturally occurring biflavone bearing a *C*-methyl group on a flavone nucleus⁷³. Another biflavone bilobetin (62) has been isolated from *C. koreana nakai* by Yook *et al.*⁷⁴ along with other biflavones, i.e. amentoflavone-4',4''',7',7'''-tetramethyl ether (61), sciadopitysin (67) and ginkgetin (63). Recently, Kuo *et al.*⁷⁵ have reported a novel cytotoxic *C*-methylated biflavone

taiwanhomoflavone (69) from *C. wilsoniana*. Different biflavones isolated from *Cephalotaxus* species are listed in Table 2.

Table 2. Biflavones from *Cephalotaxus* species

Isolated compd.	Species	Ref.
Amentoflavone (60)	<i>C. drupacea</i>	76
	<i>C. griffithii</i>	77
	<i>C. harringtonia</i>	72, 73
	(var. <i>harringtonia</i>)	
Amentoflavone-4', 4'''', 7', 7''-tetramethyl ether (61)	<i>C. fortunei</i>	78
	<i>C. harringtonia</i>	72, 73
	(var. <i>harringtonia</i>)	
	<i>C. koreana nakai</i>	74
Bilobetin (62)	<i>C. oliveri</i>	79
	<i>C. koreana nakai</i>	74
Ginkgetin (63)	<i>C. drupacea</i>	76
	<i>C. griffithii</i>	77
	<i>C. harringtonia</i>	72
	(var. <i>harringtonia</i>)	
Kayaflavone (64)	<i>C. koreana nakai</i>	74
	<i>C. drupacea</i>	80
	<i>C. harringtonia</i>	72
	(var. <i>harringtonia</i>)	
6-C-Methyl-7-O-methyl-amentoflavone (65)	<i>C. griffithii</i>	77
	<i>C. harringtonia</i>	73, 81
Oliveriflavone (66)	<i>C. oliveri</i>	79
Sciadopitysin (67)	<i>C. drupacea</i>	76
	<i>C. fortunei</i>	78
	<i>C. harringtonia</i>	72
	(var. <i>harringtonia</i>)	
Sequoiiflavone (68)	<i>C. koreana nakai</i>	74
	<i>C. oliveri</i>	79
	<i>C. drupacea</i>	76
	<i>C. griffithii</i>	77
Taiwanhomoflavone-A (69)	<i>C. harringtonia</i>	73
	(var. <i>drupacea</i>)	
	<i>C. harringtonia</i>	72
	(var. <i>harringtonia</i>)	
	<i>C. wilsoniana</i>	75

Flavones

Various flavones isolated from different *Cephalotaxus* species are compiled in Table 3.

Table 3. Flavones from *Cephalotaxus* species

Isolated compd.	Species	Ref.
Apigenin (70)	<i>C. griffithii</i>	77
Cephalotaxoside (71)	<i>C. drupacea</i>	82
Chrysoeriol (72)	<i>C. fortunei</i>	83
Kaempferol-3-O-rutinoside (73)	<i>C. follicularis</i>	84
Luteolin-7-O-glucoside (74)	<i>C. follicularis</i>	84
Myricetin-3-O-glucoside (75)	<i>C. follicularis</i>	84
Myricetin-3-O-rutinoside (76)	<i>C. follicularis</i>	84
Quercetin (77)	<i>C. griffithii</i>	82
Quercetin-3-O-glucoside (78)	<i>C. follicularis</i>	84
Quercetin-3-O-rhamnoside (79)	<i>C. follicularis</i>	84
	<i>C. griffithii</i>	77
Quercetin-3-O-rutinoside (80)	<i>C. follicularis</i>	84

Sterols

Most of the sterols occurring in *Cephalotaxus* species have been isolated from *C. drupacea*⁸⁵ (Table 4). Among them, β -sitosterol has been found to be present in abundance. We have isolated withaferin A (81) from *C. griffithii*⁸⁶. This is the first report of the occurrence of

- 70 $R_1=R_4=R_5=H$; $R_2=R_3=OH$
 71 $R_1=R_4=R_5=H$; $R_2=O$ -rhamnosyl; $R_3=OH$
 72 $R_1=R_5=H$; $R_2=R_3=OH$; $R_4=OCH_3$
 73 $R_1=O$ -rutinosyl; $R_2=R_3=OH$; $R_4=R_5=H$
 74 $R_1=R_5=H$; $R_2=R_4=OH$; $R_3=O$ -glucosyl
 75 $R_1=O$ -glucosyl; $R_2=R_3=R_4=R_5=OH$
 76 $R_1=O$ -rutinosyl; $R_2=R_3=R_4=R_5=OH$
 77 $R_1=R_2=R_3=R_4=OH$; $R_5=H$
 78 $R_1=O$ -glucosyl; $R_2=R_3=R_4=OH$; $R_5=H$
 79 $R_1=O$ -rhamnosyl; $R_2=R_3=R_4=OH$; $R_5=H$
 80 $R_1=O$ -rutinosyl; $R_2=R_3=R_4=OH$; $R_5=H$

withaferin A (81) from the family and it has been reported to possess significant inhibitory activity against sarcoma 180 (tumour), sarcoma black and the mammary adenocarcinoma in mice⁸⁷ and also antifungal activity⁸⁸.

Table 4. Sterols isolated from *Cephalotaxus* species

Isolated compd.	Species	Ref.
Campesterol	<i>C. drupacea</i>	85
Cholesterol	<i>C. drupacea</i>	85
24-Methylencholesterol	<i>C. drupacea</i>	85
β -Sitosterol	<i>C. drupacea</i>	85
	<i>C. griffithii</i>	86
Stigmasterol	<i>C. drupacea</i>	85
Withaferin A (81)	<i>C. griffithii</i>	86

Miscellaneous compounds

Besides alkaloids, flavones, bisflavones, sterols, a few other class of compounds, i.e. taxanes, fatty acids, carbohydrates, lactones have also been isolated from different *Cephalotaxus* species.

Harringtonolide (85), a plant growth inhibitory tropone, was isolated from *C. harringtonia* by Buta *et al.*⁸⁹. An an-

titumour compound, hainanolide (**83**) was isolated for the first time from *C. hainanensis*^{45,90} and later on from *C. fortunei*⁹¹ and *C. sinensis*²⁰. Hainanolide in tissue culture was noticed to have a plaque formation inhibiting activity against influenza virus type A (WS), Newcastle disease virus, Jap. B encephalitis virus⁸⁶ and vaccinia virus⁹². Chen and Luo⁹³ isolated novel 10-deacetylbaccatin-III (**82**) from the leaves of *C. sinensis*.

Table 5. Miscellaneous compounds from *Cephalotaxus* species

Isolated compd.	Species	Ref.
10-Deacetylbaccatin-III (82)	<i>C. sinensis</i>	93
Hainanolide (83)	<i>C. fortunei</i>	91
	<i>C. hainanensis</i>	45, 90
	<i>C. sinensis</i>	20, 94
Hainanolidol (84)	<i>C. hainanensis</i>	39, 46, 90, 95
Harringtonolide (85)	<i>C. harringtonia</i> (var. <i>harringtonia</i>)	89
meso-Inositol	<i>C. fortunei</i>	41
Linoleic acid	<i>C. drupacea</i>	85
Oleic acid	<i>C. drupacea</i>	85
Palmitic acid	<i>C. drupacea</i>	85
Sucrose	<i>C. griffithii</i>	86
Fortunolides A (86)	<i>C. fortunei</i>	39
Fortunolides B (87)	<i>C. fortunei</i>	39

Several fatty acids have been isolated from *C. drupacea*. The major fatty acids were unsaturated ones which predominated over the saturated ones. Oleic and linoleic acids were the main unsaturated compounds and palmitic acid was the most abundant saturated fatty acid⁸⁵. meso-Inositol, a sugar, was isolated from *C. fortunei*⁴¹. Du *et al.*³⁹ isolated two new lactones, fortunolides A (**86**) and B (**87**) alongwith compounds, hainanolidol (**84**), acetyl cephalotaxine (**1**) and wilsonine (**59**) from *C. fortunei*.

Conclusion

The *Cephalotaxus* genus is found to contain mainly alkaloids with typical carbon skeleton and having interesting and potent antitumour and antileukemic properties, besides a number of biflavones, flavones, taxanes, sterols and acids. The unique structures and potent antileukemic activities of the cephalotaxine and homoerythrina alkaloids of this genus, have drawn attention of many chemists. Our endeavour will help to locate the comprehensive information on this genus.

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