

## Letter

**New source for L-idoitol and taxanes \*****Xi-Kui Liu\*, Jian-Jun Liu**

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**Abstract:** We describe the first report of the recovery of L-idoitol and Taxane from an angiosperm- *Yunnanopilia longistaminata* (W.Z.Li) C.Y.Wu et D.Z.Li (Opiliaceae). Two taxane compounds and L-idoitol were isolated from the tender burgeon of *Yunnanopilia longistaminata*, and their structure were identified as Taxayunnansin B, Taxumairol E and L-idoitol on the basis of NMR and MS spectrum, respectively. It is a new plant source for L-idoitol and taxanes.

**Keywords:** taxane, L-idoitol, new source, *Yunnanopilia longistaminata*

Currently, plants are well recognized as a potential source of useful compounds. The L-idoitol, because of its good function, is the food sweet flavor and the important raw material of intermediates with synthesis. It is present in the fruits' juices of Genus *Sorbus spp.* in minute quantities, and able not to be extracted from the natural plant resources generally, and product by synthesis or ferment with the yeast<sup>1,2</sup>. The produce craft of it was very complicated, and the cost is very expensive.

Taxanes are complex diterpenoids typically found in yew trees of the genus *Taxus*. The most well known taxane are paclitaxel(taxol) and docetaxel(taxotere). Taxol was originally extracted from the bark of the Pacific yew (*Taxus brevifolia* Nutt)<sup>3,4</sup> and later extracted from other related gymnosperms. Since taxol and related taxanes may also be produced by endophytic bacteria in yew trees such as *Taxomyces andreanae*<sup>3</sup> and *Pestalotiopsis microspore*<sup>4,5</sup>. Hoffman and her colleagues determined that a Eastern Filbert blight resistance of Gasaway tress and fungi living on it make paclitaxel and taxane, but only at about 10% of the concentration in yew trees. Limited presence of Taxol in trees other than the yew has caused manufacturers to depend heavily on semisynthetic production using a starting-materials compound closely related to Taxol and docetaxel<sup>6</sup>. Until now, taxane is harvested mainly from *Taxus spp.*, and be found hardly from other plant.

*Yunnanopilia longistaminata* (W.Z.Li) C.Y.Wu et D.Z.Li (Opiliaceae)<sup>7</sup>, is a monotype genus plant arborescently and mainly distributed along the Red River Valley at semitropical forests at altitudes of 900-1500 meters in Yunnan, China (see Fig.1). The tender burgeon and inflorescences of it are used as an edible wild vegetable in Chinese folk (see Fig.2). The taste is very delicious as a soup or stir-frying with the tender burgeon and inflorescences of it. Now this plant is begin to cultivate in Yuanjiang county of Yunnan, China (see Fig.3). But up to now, the chemical constituents of this plant

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have not been reported. Our investigation on this plant led to the isolation of two taxane (**1** and **2**) and L-idoitol (**3**), the structures of them see Fig.4).

Their structures were identified as Taxayunnansin B(**1**)<sup>8</sup>, Taxumairol E(**2**)<sup>9</sup> and L-idoitol(**3**)<sup>10</sup> on the basis of NMR and MS spectrum with comparison of their spectral data previously, respectively.

Taxayunnansin B(**1**), colorless needle crystal (CHCl<sub>3</sub>), C<sub>35</sub>H<sub>44</sub>O<sub>13</sub>, m.p. 318~319 °C. UV λ<sub>max</sub><sup>MeOH</sup>: 205, 229, 271nm; FAB<sup>+</sup>-MS (positive) m/z: 673 [M+H]<sup>+</sup>, 551, 491, 431, 373, 329, 311, 253, 173, 105 (100). <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>): δ<sub>H</sub> 6.09(d, J=7.8Hz, 1H, 2-H), 3.12(d, J=7.8Hz, 1H, 3-H), 4.93 (d, J=7.8Hz, 1H, 5-H), 2.22, 1.60(m, 2×1H, 6-CH<sub>2</sub>), 4.48(d, J=7.8Hz, 1H, 7-H), 6.13(d, J=11.8Hz, 1H, 9-H), 6.51(d, J=11.8 Hz, 1H, 10-H), 5.52(t, J= 8.2Hz, 1H, 13-H), 2.50, 1.88 (m, 2×1H, 14-CH<sub>2</sub>), 1.05(s, 3H, 16-H), 1.66(s, 3H, 17-CH<sub>3</sub>), 1.72(s, 3H, 18-CH<sub>3</sub>), 1.15(s, 3H, 19-CH<sub>3</sub>), 4.46, 4.38(d, J=7.6Hz, 2×1H, 20-CH<sub>2</sub>), 2.00, 2.00, 2.05, 2.14(s, 4 × 3H, 4 × CH<sub>3</sub>-acetyl], 7.82(d, J=7.6Hz, 2H, o-CH-benzoyl), 7.39(t, J=7.7Hz, 2H, m-CH-benzoyl), 7.52 (t, J=7.4 Hz, 1H, p-CH-benzoyl), 2.07(d, J=6.8Hz, 1H, 7-OH), 2.71(s, 1H, 15-OH) ppm; <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>): δ<sub>C</sub> 67.6(s, C-1), 69.1(d, C-2), 44.0(d, C-3), 79.8(s, C-4), 84.9(d, C-5), 34.7(t, C-6), 67.9(d, C-7), 43.6(s, C-8), 76.7 (d, C-9), 77.0(d, C-10), 133.8(s, C-11), 151.4(s, C-12), 70.3(d, C-13), 39.5(t, C-14), 74.9(s, C-15), 12.5(q, C-16), 25.2(q, C-17), 27.4(q, C-18), 11.8(q, C-19), 75.4(t, C-20), 20.5, 21.3, 21.5, 22.3(q, 4×CH<sub>3</sub>-acetyl], 169.7, 169.7, 170.3, 171.0(s, 4 × C=O-acetyl], 164.0(s, C=O-benzoyl), 129.0(s, C-benzoyl), 129.4(d, 2',6'-CH-benzoyl), 128.7(d, 3',5'-CH-benzoyl), 133.3(d, 4'-CH-benzoyl) ppm.

Taxumairol E(**2**), colorless sheet crystal (CH<sub>3</sub>COCH<sub>3</sub>), C<sub>30</sub>H<sub>44</sub>O<sub>12</sub>, m.p. 230~232 °C, [α]<sub>D</sub><sup>25</sup>+ 54.9 (CHCl<sub>3</sub>, c 0.75). UV λ<sub>max</sub><sup>MeOH</sup> (log ε) nm: 225 (3.60). IR ν<sub>max</sub> cm<sup>-1</sup>: 3468, 2936, 1740, 1462, 1440, 1376, 1246, 1026, 992, 754. ESI-MS(positive) m/z: 619[M+Na]<sup>+</sup>, 559, 537 (100), 477, 417. <sup>1</sup>H NMR(400MHz, CD<sub>3</sub>OD): δ<sub>H</sub> 2.00(m, 1H, 1-H), 4.28 (d, J=3.9Hz, 1H, 2-H), 2.58(m, 1H, 3-H), 2.00(m, 1H, 4-H), 5.05(m, 1H, 5-H), 2.00, 1.70(m, 1H×2, 6-H), 5.37(dd, J=11.7, 5.1Hz, 1H, 7-H), 5.77 (d, J=11.0Hz, 1H, 9-H), 6.16(d, J=11.0Hz, 1H, 10-H), 5.94(dd, J=7.8, 8.4Hz, 1H, 13-H), 2.59, 1.60(m, 2×1H, 14-CH<sub>2</sub>), 1.68(s, 3H, 16-CH<sub>3</sub>), 1.16(s, 3H, 17-CH<sub>3</sub>), 2.20(s, 3H, 18-CH<sub>3</sub>), 0.93(s, 3H, 19-CH<sub>3</sub>), 3.99(dd, J=10.5, 2.1Hz, 1H, 20α-H), 3.30 (m, 1H, 20β-H), 2.11, 2.04, 2.02, 1.96, 2.21(s, 5×3H, 5×CH<sub>3</sub>-acetyl)ppm; <sup>13</sup>C NMR(100MHz, CD<sub>3</sub>OD): δ<sub>C</sub> 51.7(d, C-1), 71.3(d, C-2), 40.7(d, C-3), 46.8(d, C-4), 70.0(d, C-5), 30.0(t, C-6), 69.1(d, C-7), 45.7 (s, C-8), 75.8(d, C-9), 71.7(d, C-10), 133.3(s, C-11), 137.6(s, C-12), 70.6(d, C-13), 27.6(t, C-14), 37.8(s, C-15), 27.3(q, C-16), 31.8(q, C-17), 14.9(q, C-18), 14.2(q, C-19), 65.0(t, C-20), 21.4, 20.9, 20.8, 21.5, 21.7(q, 5×CH<sub>3</sub>-acetyl], 169.7, 169.1, 170.0, 170.4, 170.4(s, 5×C=O-acetyl) ppm.

L-idoitol(**3**), C<sub>6</sub>H<sub>14</sub>O<sub>6</sub>, M=182. m.p.73-75°C. ESI m/z: 363[2M-1], 181[M-1], 163[M-1-H<sub>2</sub>O]. <sup>1</sup>H NMR(400MHz, D<sub>2</sub>O): δ<sub>H</sub> 3.66(dd, J=2.6, 11.6Hz, 2H, 1β, 6β-H), 3.74(ddd, J=8.6, 6.0, 2.6Hz, 2H, 3,4-H), 3.78(d, J=8.6Hz, 2H, 2,5-H), 3.85(dd, J=2.6, 11.6Hz, 2H, 1α, 6α-H)ppm. <sup>13</sup>C NMR(400MHz, D<sub>2</sub>O): δ<sub>C</sub> 66.0(C-1,6). 72.0(C-3,4), 73.5(C-2,5)ppm.

The results presented here show that at least some, and perhaps all, of the L-idoitol and taxane present in *Yunnanopilia longistaminata*. Yet, we have not ruled out that, in addition, the plant may produce its own Taxol, but it is a new source of L-idoitol and taxane.

## METHODS SUMMARY

The fresh tender burgeons of *Yunnanopilia longistaminata* was extracted exhaustively with 90% EtOH and fractionated by successive partition with EtOAc, then subjected to silica gel column chromatography with a CHCl<sub>3</sub>-MeOH and Lichroprep RP-18 gel column chromatography with MeOH-H<sub>2</sub>O to yield Taxayunnansin B(**1**)<sup>8</sup>, Taxumairol E(**2**). The H<sub>2</sub>O fraction was crystallized with 80% EtOH-H<sub>2</sub>O to provide L-Iditol(**3**).

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**Author Contribution** J.-J. Liu performed the isolation and identification the structure of Taxayunnansin B, Taxumairol E. X.-K. Liu collected the plant materials, isolated and identified the structure of L-Iditol, supervised the project and wrote the manuscript.

**Author Information** The plant material was authenticated by Prof. Chun-Chao Lv, and a voucher specimem (No.KIB 05-04-10) was deposited at the State Key Laboratory of Phytochemistry and Plant Resources in West China, Kunming Institute of Botany, Chinese Academy of Sciences, P.R.China. Reprints and permissions information is available at [www.nature.com/reprints](http://www.nature.com/reprints). Correspondence and requests for material should be addressed to Xi-Kui Liu ([liuxikui@mail.kib.ac.cn](mailto:liuxikui@mail.kib.ac.cn)).

## METHODS

Melting points were obtained on an X-4 Digital Melting apparatus and were uncorrected. Optical rotations were carried out on a Perkin-Elmer model 241 polarimeter. IR spectra were measured in a Bio-Rad FTS-135 spectrometer with KBr pellets. MS were recorded on a VG Auto spec-3000 spectrometer and a Finnigan MAT 90 instrument. NMR spectra were taken on a Bruker AM-400 and a Bruker DRX-500 instrument with TMS as an internal standard, respectively. Column chromatography were performed either on silica gel (200-300 mesh, Qingdao Marine Chemical Inc., China), silica gel H (10-40 $\mu$ m, Qingdao Marine Chemical Inc., China), or Lichroprep RP-18 gel (40-63 $\mu$ m, Merck, Dramstadt, Germany).

The fresh tender burgeons of *Yunnanopilia longistaminata* was collected at April 2005, from Shiping, Yunnan Province, and was identified by Prof. Chun-Chao Lv of the Kunming Institute of Botany, Chinese Academy of Sciences. A voucher specimen (No.KIB 05-04-10) was deposited at the State Key Laboratory of Phytochemistry and Plant Resources in West China, Kunming Institute of Botany, Chinese Academy of Sciences, P.R.China.

The fresh tender burgeons of *Yunnanopilia longistaminata* (10kg) was cut into pieces with a knife and extracted exhaustively with 90% EtOH at room temperature. The EtOH extract was evaporated at 45 $^{\circ}$ C to yield a black syrup-like residue (570g) under reduces pressure. The residue was suspended in H<sub>2</sub>O and fractionated by successive partition with petroleum ether, EtOAc, and n-BuOH to give petroleum ether soluble (62g), EtOAc-soluble (141g) and n-BuOH-soluble fractions (127g), respectively. The EtOAc extract (141g) was subjected to silica gel column chromatography, eluted with a CHCl<sub>3</sub>-MeOH (10:0, 9:1, 8:2, 7:3, 6:4, 0:1v/v) gradiently to give four fractions according to TLC of silica gel H with CHCl<sub>3</sub>-MeOH(4:1). Fraction II (4.2g) was subjected to silica gel column chromatography with CHCl<sub>3</sub>-MeOH (4:1) and Lichroprep RP-18 gel column chromatography with MeOH-H<sub>2</sub>O (1:1) to yield Taxayunnansin B(2.0g) and Taxumairol E(10mg). The H<sub>2</sub>O fraction was concentrated under reduced pressure, and crystallized with 80% EtOH-H<sub>2</sub>O to provide compound **3**(27g).



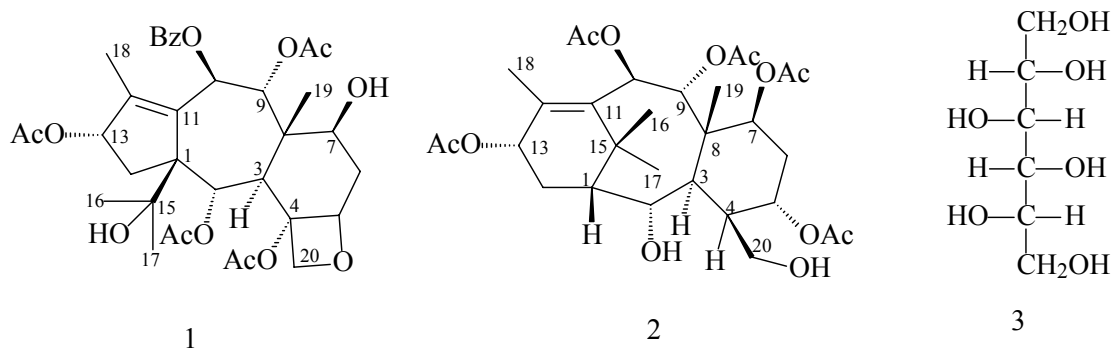
**FIG. 1** The tree of *Yunnanopilia longistaminata* (W.Z.Li) C.Y.Wu et D.Z.Li. It is monotypic genus plant and mainly distributed along the Red River Valley and occurs at semitropical forests at altitudes of 900-1500 meters in Yunnan, China,



**FIG. 2** The twig and leaves of *Yunnanopilia longistaminata* (W.Z.Li) C.Y.Wu et D.Z.Li. The tender burgeon of it is used as an edible wild vegetable in Chinese folk. The taste is very delicious as a soup or stir-frying with the tender burgeon and inflorescences of it.



**FIG. 3** The young seedling of *Yunnanopilia longistaminata* (W.Z.Li) C.Y.Wu et D.Z.Li. It is cultivated with seed in the Yuanjiang county of Yunnan, China.



**FIG. 2** Structures of taxayunnansin B(1), taxumairol E(2) and L-iditol(3). Abbreviations for chemical groups: OBz, benzoyl; OAc, acetyl. Selected physical data for compound 1:  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ):  $\delta_{\text{H}}$  6.09(d,  $J=7.8\text{Hz}$ , 1H, 2-H), 3.12(d,  $J=7.8\text{Hz}$ , 1H, 3-H), 4.93 (d,  $J=7.8\text{Hz}$ , 1H, 5-H), 2.22, 1.60(m,  $2\times 1\text{H}$ , 6- $\text{CH}_2$ ), 4.48(d,  $J=7.8\text{Hz}$ , 1H, 7-H), 6.13(d,  $J=11.8\text{Hz}$ , 1H, 9-H), 6.51(d,  $J=11.8\text{Hz}$ , 1H, 10-H), 5.52(t,  $J=8.2\text{Hz}$ , 1H, 13-H), 2.50, 1.88 (m,  $2\times 1\text{H}$ , 14- $\text{CH}_2$ ), 1.05(s, 3H, 16-H), 1.66(s, 3H, 17- $\text{CH}_3$ ), 1.72(s, 3H, 18- $\text{CH}_3$ ), 1.15(s, 3H, 19- $\text{CH}_3$ ), 4.46, 4.38(d,  $J=7.6\text{Hz}$ ,  $2\times 1\text{H}$ , 20- $\text{CH}_2$ ), 2.00, 2.00, 2.05, 2.14(s,  $4\times 3\text{H}$ ,  $4\times \text{CH}_3$ -acetyl], 7.82(d,  $J=7.6\text{Hz}$ , 2H, o-CH-benzoyl), 7.39(t,  $J=7.7\text{Hz}$ , 2H, m-CH-benzoyl), 7.52 (t,  $J=7.4\text{Hz}$ , 1H, p-CH-benzoyl), 2.07(d,  $J=6.8\text{Hz}$ , 1H, 7-OH), 2.71(s, 1H, 15-OH) ppm;  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ):  $\delta_{\text{C}}$  67.6(s, C-1), 69.1(d, C-2), 44.0(d, C-3), 79.8(s, C-4), 84.9(d, C-5), 34.7(t, C-6), 67.9(d, C-7), 43.6(s, C-8), 76.7 (d, C-9), 77.0(d, C-10), 133.8(s, C-11), 151.4(s, C-12), 70.3(d, C-13), 39.5(t, C-14), 74.9(s, C-15), 12.5(q, C-16), 25.2(q, C-17), 27.4(q, C-18), 11.8(q, C-19), 75.4(t, C-20), 20.5, 21.3, 21.5, 22.3(q,  $4\times \text{CH}_3$ -acetyl], 169.7, 169.7, 170.3, 171.0(s,  $4\times \text{C}=\text{O}$ -acetyl], 164.0(s,  $\text{C}=\text{O}$ -benzoyl), 129.0(s, C-benzoyl), 129.4(d, 2',6'-CH-benzoyl), 128.7(d, 3',5'-CH-benzoyl), 133.3(d, 4'-CH-benzoyl) ppm. UV  $\lambda_{\text{max}}^{\text{MeOH}}$ : 205, 229, 271nm; FAB<sup>+</sup>-MS (positive) m/z: 673 [M+H]<sup>+</sup>, 551, 491, 431, 373, 329, 311, 253, 173, 105 (100). Compound 2:  $^1\text{H}$  NMR(400MHz,  $\text{CD}_3\text{OD}$ ):  $\delta_{\text{H}}$  2.00(m, 1H, 1-H), 4.28 (d,  $J=3.9\text{Hz}$ , 1H, 2-H), 2.58(m, 1H, 3-H), 2.00(m, 1H, 4-H), 5.05(m, 1H, 5-H), 2.00, 1.70(m,  $1\text{H}\times 2$ , 6-H), 5.37(dd,  $J=11.7, 5.1\text{Hz}$ , 1H, 7-H), 5.77 (d,  $J=11.0\text{Hz}$ , 1H, 9-H), 6.16(d,  $J=11.0\text{Hz}$ , 1H, 10-H), 5.94(dd,  $J=7.8, 8.4\text{Hz}$ , 1H, 13-H), 2.59, 1.60(m,  $2\times 1\text{H}$ , 14- $\text{CH}_2$ ), 1.68(s, 3H, 16- $\text{CH}_3$ ), 1.16(s, 3H, 17- $\text{CH}_3$ ), 2.20(s, 3H, 18- $\text{CH}_3$ ), 0.93(s, 3H, 19- $\text{CH}_3$ ), 3.99(dd,  $J=10.5, 2.1\text{Hz}$ , 1H, 20 $\alpha$ -H), 3.30 (m, 1H, 20 $\beta$ -H), 2.11, 2.04, 2.02, 1.96, 2.21(s,  $5\times 3\text{H}$ ,  $5\times \text{CH}_3$ -acetyl]ppm;  $^{13}\text{C}$  NMR(100MHz,  $\text{CD}_3\text{OD}$ ):  $\delta_{\text{C}}$  51.7(d, C-1), 71.3(d, C-2), 40.7(d, C-3), 46.8(d, C-4), 70.0(d, C-5), 30.0(t, C-6), 69.1(d, C-7), 45.7 (s, C-8), 75.8(d, C-9), 71.7(d, C-10), 133.3(s, C-11), 137.6(s, C-12), 70.6(d, C-13), 27.6(t, C-14), 37.8(s, C-15), 27.3(q, C-16), 31.8(q, C-17), 14.9(q, C-18), 14.2(q, C-19), 65.0(t, C-20), 21.4, 20.9, 20.8, 21.5, 21.7(q,  $5\times \text{CH}_3$ -acetyl], 169.7, 169.1, 170.0, 170.4, 170.4(s,  $5\times \text{C}=\text{O}$ -acetyl] ppm. UV  $\lambda_{\text{max}}^{\text{MeOH}}$  (log  $\epsilon$ ) nm: 225 (3.60). IR  $\nu_{\text{max}}$   $\text{cm}^{-1}$ : 3468, 2936, 1740, 1462, 1440, 1376, 1246, 1026, 992, 754. ESI-MS(positive) m/z: 619[M+Na]<sup>+</sup>, 559, 537 (100), 477, 417. Compound 3:  $^1\text{H}$  NMR(400MHz,  $\text{D}_2\text{O}$ ):  $\delta_{\text{H}}$  3.66(dd,  $J=2.6, 11.6\text{Hz}$ , 2H, 1 $\beta$ , 6 $\beta$ -H), 3.74(ddd,  $J=8.6, 6.0, 2.6\text{Hz}$ , 2H, 3,4-H), 3.78(d,  $J=8.6\text{Hz}$ , 2H, 2,5-H), 3.85(dd,  $J=2.6, 11.6\text{Hz}$ , 2H, 1 $\alpha$ , 6 $\alpha$ -H)ppm.  $^{13}\text{C}$  NMR(400MHz,  $\text{D}_2\text{O}$ ):  $\delta_{\text{C}}$  66.0(C-1,6). 72.0(C-3,4), 73.5(C-2,5)ppm. ESI m/z: 363[2M-1], 181[M-1], 163[M-1-H<sub>2</sub>O].