Compound **1** Colourless oil IR ν_{max} cm^{-1} 3500, 1150, 1040; ^1H NMR ($CDCl_3$). δ 1 19 (3H, *d*, $J = 6.7$ Hz), 1 26 (3H, *s*), 1.32 (3H, *s*), 1 49 (1H, *dd*, $J_1 = 14.6$ $J_2 = 2.4$ Hz), 1.66 (1H, *dd*, $J_1 = 14.6$ $J_2 = 10.0$ Hz), 4.21 (1H, *ddc*, $J_1 = 12.3$ $J_2 = 10.0$ $J_3 = 6.2$ $J_4 = 2.4$ Hz)

Compound **17a** Colourless oil

λ	598	578	546	436	365
α	−2 7	−3.0	−3 3	−8.0	−18 0

($CHCl_3$, *c* 1 02%) IR ν_{max} cm^{-1}. 3060, 1730, 1635, 1230, 1020, 930, 880, 800; ^1H NMR ($CDCl_3$)· δ 0 73 (3H, *s*), 1.01 (6H, *d* $J = 6.9$ Hz), 2.04 (3H, *s*), 4 71 (1H, *dd* $J_1 = 11.8$ $J_2 = 4.5$ Hz), 4.66 (1H, *d* $J = 1.4$ Hz), 4 85 (1H, *d* $J + 1.4$ Hz), 5 27 (1H, *m*) ^{13}C NMR (Table 1)

Compound **18** Semisolid product.

λ	589	578	546	436
α	277 0	290 7	337 2	639.8

($CHCl_3$; *c* 1 01%) IR ν_{max} cm^{-1}. 3100, 2220, 2120, 1750, 1650, 1630, 1580, 1230, 1030, 970, 915, 850, 800. ^1H NMR and ^{13}C NMR, see Tables 2 and 3

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KANSHONES D AND E, SESQUITERPENOIDS OF *NARDOSTACHYS CHINENSIS* ROOTS*

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Key Word Index—*Nardostachys chinensis*; Valerianaceae; sesquiterpenoid; kanshones D and E.

Abstract—Two new minor sesquiterpenoids, kanshones D and E, were isolated from *Nardostachys chinensis* along with isonardosinone, nardosinone diol, and nardofuran. The structures of kanshones D and E were elucidated by spectral means together with chemical transformation.

The crude drug, 'kanshoko' (Chinese spikenard), prepared from the rhizomes and roots of the valerianaceous plant *Nardostachys chinensis* Batalin (Valerianaceae), is used in the Oriental system of medicine for stomachic and sedative purposes, and is known to elaborate a number of sesquiterpenoids [1–11]. During the phytochemical investigation of this plant, we have so far isolated an iridoid, nardochin, and sesquiterpenoids, kanshones A, B and C, together with its known constituent nardosinone [12–14]. Further reinvestigation of the methylene chloride extract of this plant material has resulted in the isolation of two minor sesquiterpenoids kanshones D (**1**) and E (**2**) in addition to isonardosinone (**3**), nardosinone diol (**4**) and nardofuran (**5**), the latter two of which were previously reported as reaction products of nardosinone

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[5, 15] The advancement of the structures for kanshones D and E were mainly based on spectral data and chemical transformation

Kanshone D, was shown to possess the molecular formula $C_{15}H_{22}O_4$ on the basis of its molecular ion peak at *m/z* 266 and its ^{13}C NMR spectrum The UV absorption maximum at 251 nm and IR spectral bands at 3450 and 1698 cm^{-1} inferred that kanshone D has a hydroxyl group and a conjugated carbonyl function. In the ^1H NMR spectrum, signals due to hydrogens of an ABX type (δ 2 34 (1H, *d*, *J* = 6 2 Hz), 3 40 (1H, *d*, *J* = 3 2 Hz) and 3 65 (1H, *dd*, *J* = 6 2 and 3 2 Hz)) as well as one secondary methyl and three tertiary methyl groups appeared essentially at the same positions as those of C-6, C-8, C-7 and four methyl hydrogen signals of isonardosinone (**3**), pointing out a structural similarity between these two compounds However, kanshone D exhibited an olefinic hydrogen signal at δ6 84 as a doublet (1H, *J* = 5 7 Hz), whereas isonardosinone (**3**) displayed the corresponding signal at δ6.97 as a triplet (1H, *J* = 4 2 Hz) Moreover, an extra carbinyl hydrogen signal at δ4 22 (1H, *m*), which was shifted downfield to δ5 22 (1H, *m*) in its monoacetate (**1a**), was also discernible in the ^1H NMR spectrum of kanshone D. These findings, in connection with the difference in the molecular formula between kanshone D and isonardosinone (**3**) by an extra oxygen atom, revealed that kanshone D bears a hydroxyl group at C-2 The orientation of this hydroxyl group was shown to be spatially close to the C-4 hydrogen from the distinct downfield shift ($\Delta\delta$ 0 40 ppm) of the C-4 methine hydrogen signal at δ2 95 (1H, *m*) and the significant upfield shift ($\Delta\delta$ −7 6 ppm) of the C-4 carbon signal at δ25 5 (*d*) as compared to those of isonardosinone (**3**) (δ2 55 (1H, *m*) and δ33 1 (*d*), respectively) The Cotton effects in the CD spectrum of kanshone D have the identical signs to those of isonardosinone (**3**), inferring that both compounds have the same absolute configurations Accordingly, kanshone D was found to be **1**, which is also confirmed by comparison of ^{13}C NMR spectrum of kanshone D with that of isonardosinone (**3**) not reported earlier (Table 1)

Kanshone E (**2**), obtained as a gummy residue, was proved to have the molecular formula $C_{15}H_{20}O_4$ from its mass spectral peak at *m/z* 264 and an analysis of its ^{13}C NMR spectrum Like its other congeners the ^1H NMR spectrum spoke the presence of hydrogens of an ABX type (δ3.72 (1H, *dd*, *J* = 6 2 and 3.3 Hz), 3 51 (1H, *d*, *J* = 3 3 Hz) and 2 48 (1H, *d*, *J* = 6.2 Hz), one secondary methyl and three tertiary methyl groups in kanshone E Further, an olefinic hydrogen signal at δ6 69 as a singlet and two carbonyl carbon signals at δ199 3 and 193 7 (each *s*) led to the conclusion that kanshone E is the dehydro derivative of kanshone D In order to confirm the alleged structure as well as the absolute configurations on chiral centers of kanshone E, allylic oxidation of kanshone D was carried out to afford a compound which was identical with kanshone E (TLC, mass and ^1H NMR spectra), revealing identical stereochemistry for these two compounds. The structure of kanshone E thus deduced was well corroborated with its ^{13}C NMR spectrum (Table 1)

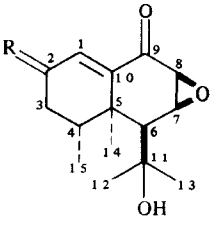
EXPERIMENTAL

Isolation of kanshones D and E Dried rhizomes and roots (4 5 kg) of *Nardostachys chinensis* were extracted with CH_2Cl_2 (6 l × 3) to afford a brown oil (200 g), which was chromatographed over silica gel (1 kg) The column was eluted with *n*-hexane and *n*-hexane–EtOAc mixtures of increasing polarity Rechromatography of one of the portion of the *n*-hexane–EtOAc (1 1) eluates (10 0 g) of the above column over silica gel (0 5 kg) using hexane–Me_2CO (4 1) yielded isonardosinone, nardosinone diol, nardofuran followed by kanshone D (**1**) as colourless needles (12 mg) and gummy kanshone E (**2**) (17 mg)

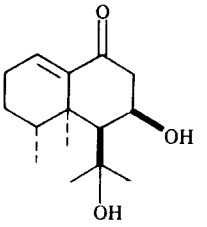
Table 1 ^{13}C NMR spectra of **1**–**5** (25 0 MHz, $CDCl_3$)

C	1	2	3	4†	5
1	134 0 *d*	130 0 *d*	139 4 *d*	136 7 *d*	137 3 *d*
2	61 5 *d*	*199 3 *s*	*26 0 *t*	*26 3 *t*	*25 5 *t*
3	33 7 *t*	42 1 *t*	*26 4 *t*	*25 5 *t*	*26 2 t
4	25 5 *d*	32 8 *d*	33 1 *d*	32 8 *d*	31 6 *d*
5	43 0 *s*	44 7 *s*	43 3 *s*	40 3 *s*	39 8 *s*
6	48 6 *d*	50 1 *d*	49 8 *d*	52 7 *d*	56 0 *d*
7	*52 8 *d*	*53 1 *d*	*53 4 *d*	68.3 *d*	75 7 *d*
8	*56.4 *d*	*56 8 *d*	*56 8 *d*	46.2 *t*	87 8 *d*
9	193 9 *s*	*193 7 *s*	194 0 *s*	200 6 *s*	197 7 *s*
10	142 4 *s*	155 6 *s*	140 6 *s*	142 1 *s*	141 8 *s*
11	74 7 *s*	75 3 *s*	75 1 *s*	77 9 *s*	84 9 *s*
12	*30 9 *q*	*32 7 *q*	*31 9 *q*	*37 6 *q*	*31 6 *q*
13	*28 6 *q*	*27 8 *q*	*27 7 *q*	*29 5 *q*	*31 9 *q*
14	21 5 *q*	21 8 *q*	24 9 *q*	26 0 *q*	24 3 *q*
15	16 0 *q*	17 4 *q*	17 3 *q*	16 2 *q*	15 2 *q*

*Data can be interchanged within the group
†500 MHz



1 R = α-H, β-OH
1a R = α-H, β-OAc
2 R = O
3 R = H_2



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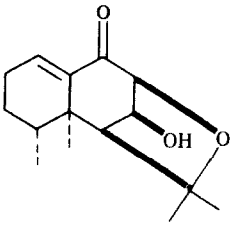

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Kanshone D (**1**) Colourless needles, mp 152–153°, $[\alpha]_D$ +57.9° ($CHCl_3$; *c* 0 52), CD $[\theta]_{350}$ −600, $[\theta]_{247}$ +2560 (dioxane; *c* 0.119), EIMS (direct inlet) 70 eV, *m/z* 266 [M^+], 234, 190, 180, 174, 161, 160, 151, 133, 120, 91, 69, 59, UV λ_{max}^{MeOH} nm (log ε) 251 (3 67), IR $\nu_{max}^{CHCl_3}$ cm^{-1} 3450, 1698, 1635, 1470, 1268, 1070, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 98 (3H, *s*, H-14), 1 00 (3H, *d*, *J* = 6 5 Hz, H-15), 1 45, 1.50 (3H, each *s*, H-12, H-13), 2 34 (1H, *d*, *J* = 6 2 Hz, H-6), 2 95 (1H, *m*, H-4), 3 40 (1H, *d*, *J* = 3 2 Hz, H-8), 3.65 (1H, *dd*, *J* = 6.2 and 3 2 Hz, H-7), 4 22 (1H, *m*, H-2), 6 84 (1H, *d*, *J* = 5 7 Hz, H-1)

Kanshone E (**2**) Gummy residue, $[\alpha]_D$ −42 2° ($CHCl_3$, *c* 1 29); EIMS (direct inlet) 70 eV, *m/z*· 264[M^+], 247, 246, 231, 228, 219, 217, 189, 162, 149, 136, 122, 120, 91, 85, 76, 71, 69, 67, 65, 59; UV λ_{max}^{MeOH} nm (log ε) 253 (3 68), IR $\nu_{max}^{CHCl_3}$ cm^{-1} 3530, 1706, 1688, 1470, 1400, 1380, 1300, 1258, ^{1}H NMR (500 MHz, $CDCl_3$) δ 1 09 (3H, *d*, *J* = 6 0 Hz, H-15), 1 26, 1 33, 1 52 (3H, each *s*, H-14, H-12, H-13), 2 25 (1H, *dd*, *J* = 16.0 and 14 0 Hz, H-3), 2 31 (1H, *dd*, *J* = 16 0 and 4.0 Hz, H-3), 2 48 (1H, *d*, *J* = 6 2 Hz, H-6), 3.25 (1H, *m*, H-4), 3.51 (1H, *d*, *J* = 3 3 Hz, H-8), 3 72 (1H, *dd*, *J* = 6 2 and 3 3 Hz, H-7), 6 69 (1H, *s*, H-1)

Acetylation of kanshone D A mixture of kanshone D (3 mg), Ac_2O (0 25 ml) and pyridine (0 25 ml) was kept under dry condition for overnight at room temp Usual work-up afforded gummy kanshone D monoacetate (**1a**) (2 5 mg); EIMS (direct inlet) 70 eV *m/z* 306 [M^+], 264 [M−42]$^+$, 248, 189, 174, 162, 161, 133, 90, 78, 76, 59, 42, ^{1}H NMR (500 MHz, $CDCl_3$) δ: 0.99 (3H, *d*, *J* = 6 3 Hz, H-15), 1 00, 1.38, 1 50 (3H, each *s*, H-14, H-12, H-13), 2 00 (3H, *s*, —OAc), 2 95 (1H, *m*, H-4), 3 40 (1H, *d*, *J* = 4.0 Hz, H-8), 3 65 (1H, *br s*, H-7), 5 22 (1H, *m*, H-2), 6 84 (1H, *s*, H-1)

Allylic oxidation of kanshone D A mixture of kanshone D (2.5 mg) and activated MnO_2 (300 mg) in Me_2CO (3 ml) was stirred for overnight at room temp. to afford kanshone E, which was identical in TLC, mass, and ^{1}H NMR spectra with natural kanshone E

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