Short Communication

New Terpenoids, Ganolucidic Acid D, Ganoderic Acid L, Lucidone C and Lucidenic Acid G, from the Fungus Ganoderma lucidum

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The fruiting body of the fungus Ganoderma lucidum (Reishi) has attracted much attention as a folk medicine, and some of its components have been elucidated. We have also reported several bitter terpenoids and related compounds from the fungus.1~9) The naming of lucidenic acids is a little confused, so we now designate our lucidenic acids D and E2) as Dx and El5 and Kikuchi’s7) as D2 and E2, respectively. Recently, we have isolated four new terpenoids, ganolucidic acid D (1), methyl ganoderate L (2a), lucidone C (3) and methyl lucidenate G (4a). Ganolucidic acid D (1) has an allylic alcohol group in the side chain and can be a possible biogenetic intermediate between the mycelial components10) and terpenoids of the fruiting body. On the other hand, ganoderic acid L (2), which has a hydroxyl group at C-20, can be a possible precursor of lucidone C (3). Among the lucidenic acids, lucidenic acid G (4) is unique in having a hydroxyl group at C-26.

The isolation procedure was the same as that described in our previous papers,1,3) and the acidic part obtained was separated into thirteen fractions (Fr. 1~13). Fr. 12 was subjected to Lobar column (RP-8, Merck) chromatography and the second fraction was treated with diazomethane. The resulting product was rechromatographed on silica gel and the Lobar (RP-8) column to give methyl ganoderate L (2a), lucidone C (3) and methyl lucidenate G (4a). The fourth fraction in the chromatography of Fr. 12 was purified on a silica gel column, PTLC and HPLC to give ganolucidic acid D (1).

Ganolucidic acid D (1), crystalline solids, C30H44O6 (M+ 500.3135). [α]D 23° +192° (c = 0.1, EtOH). UV λmax nm (ε): 257 (7800). IR νmax cm⁻¹: 3400, 1700, 1640. 1 was treated with diazomethane to yield a monomethyl ester 1a, C31H46O6 (M+ 514.3304). The 1H-NMR data of 1a were δDDS: 7.17 (1H, dq, J = 8.8 and 1.5Hz), 4.95 (1H, overlapped), 4.62 (1H, ddd, J = 8.8, 5.9 and 5.4Hz), 2.01 (3H, d, J = 1.5Hz), 1.47 (3H, s), 1.26 (3H, s), 1.13 (3H, s), 1.12 (3H, s), 1.09 (3H, d, J = 6.8Hz), 0.95 (3H, s). The 13C-NMR data of 1a were δDDS (number of bonded H): 217.1 (0),
198.3 (0), 168.6 (0), 165.5 (0), 146.2 (1), 138.2 (0), 127.3 (0), 72.0 (1), 66.7 (1). These data indicate that \( \text{Ia} \) was different from methyl ganolucidic acid A\(^{10} \) in the side chain moiety, having a double bond between C-24 and C-25, and a hydroxyl group at C-23. In the \(^1\)H-NMR spectrum of \( \text{Ia} \), the signal due to H-24 resonated at \( \delta 6.59 \) in CDCl\(_3\), which resembles those of tiglic acid\(^{11} \) and ganoderic acids U\(^{-2},10 \) so the configuration of the double bond between C-24 and C-25 was assigned as E. From these observations, the structure of ganolucidic acid D was concluded to be 15\( \alpha \),23-dihydroxy-3,11-dioxo-5\( \alpha \)-lanosta-8,24\( \beta \)-dien-26-oic acid (1).

Methyl ganoderate L (2a), colorless prisms, mp 228~230°C. [\( \alpha \]_D\( ^{+} \)=+66° (c=0.2, MeOH). UV \( \lambda_{\text{max}} \)nm (e): 256 (6750). IR \( \nu_{\text{max}} \)cm\(^{-1} \): 3430, 1720, 1655. \(^1\)H-NMR \( \delta_{\text{TMS}} \): 5.46 (1H, dd, J=9.2 and 7.3 Hz), 5.0 (1H, overlapped), 3.52 (1H, dd, J=10.6 and 5.1 Hz), 1.64 (3H, s), 1.59 (3H, s), 1.57 (3H, s), 1.54 (3H, s), 1.29 (3H, s), 1.15 (3H, d, J=6.6 Hz), 1.11 (3H, s). The \(^1\)C-NMR data showed the presence of thirty-one carbon atoms and the principal signals were 125\( \text{C} \): 209.4 (0), 176.2 (0), 160.3 (0), 141.7 (0), 176.2 (0), 160.3 (0), 141.7 (0), 77.6 (1), 73.8 (0), 72.4 (1), 69.5 (1). By comparing these data to those of methyl ganoderate D\(^2,7 \) and I\(^3 \) the structure depicted as 2a was deduced for methyl ganoderate L. The FD-MS data of 2a were \( m/\text{z} \) (\%): 548 (M\(^{+} \), 5.3), 404 (100), 144 (33.4). The very weak intensity of the molecular ion peak is attributable to the McLafferty rearrangement and subsequent easy cleavage between C-20 and C-22. The EI-MS of 2a did not give the molecular ion peak, but its fragmentation pattern was in good agreement with that of lucidine C (3). Thus, the structure of methyl ganoderate L was established to be methyl 3\( \beta \),7\( \beta \),15\( \alpha \)-trihydroxy-4\( \beta \)-hydroxymethyl-4\( \beta \)-dimethyl-3,11-dioxo-5\( \alpha \)-chol-8-ene-24-oate (2a).

Lucidine C (3), colorless syrup, C\(_{24}\)H\(_{36}\)O\(_5\) (M\(^{+} \)=490.2905). [\( \alpha \]_D\( ^{+} \)=+145° (c=0.2, MeOH). UV \( \lambda_{\text{max}} \)nm (e): 255 (7680). IR \( \nu_{\text{max}} \)cm\(^{-1} \): 3500 (sh), 3430, 1700, 1660. \(^1\)H-NMR \( \delta_{\text{TMS}} \): 5.34 (1H, dd, J=9.5 and 7.3 Hz), 4.98 (1H, dd, J=9.9 and 7.3 Hz), 3.51 (1H, dd, J=10.8 and 5.3 Hz), 2.11 (3H, s), 1.59 (3H, s), 1.51 (3H, s), 1.29 (3H, s), 1.11 (3H, s), 1.07 (3H, s). \(^1\)C-NMR \( \delta_{\text{TMS}} \): 207.6 (0), 198.9 (0), 159.9 (0), 141.9 (0), 77.5 (1), 72.4 (1), 69.4 (1). These data are very similar to those of lucidone A\(^2 \) but the presence of a 15\( \alpha \)-hydroxyl group is indicated. So the structure of lucidone C was assigned as 3\( \beta \),7\( \beta \),15\( \alpha \)-trihydroxy-4,4,14\( \alpha \)-trimethyl-11,20-dioxo-5\( \alpha \)-pregn-8-en (3).

Methyl lucidenate G (4), colorless syrup, C\(_{28}\)H\(_{42}\)O\(_7\) (M\(^{+} \)=532.3392), [\( \alpha \]_D\( ^{+} \)=+127° (c=0.2, MeOH). UV \( \lambda_{\text{max}} \)nm (e): 254 (8040). IR \( \nu_{\text{max}} \)cm\(^{-1} \): 3400, 1730 (sh), 1700, 1660. \(^1\)H-NMR \( \delta_{\text{TMS}} \): 5.24 (1H, dd, J=9.8 and 7.1 Hz), 4.99 (1H, dd, J=9.9 and 7.3 Hz), 4.37 (1H, d, J=11.0 Hz), 1.72 (3H, s), 1.52 (3H, s), 1.51 (3H, s), 1.07 (3H, s), 0.81 (3H, d, J=5.9 Hz). \(^1\)C-NMR \( \delta_{\text{TMS}} \): 214.4 (0), 199.8 (0), 174.1 (0), 161.3 (0), 140.6 (0), 72.2 (1), 69.2 (1), 65.1 (2). These data indicate that methyl lucidenate G had the structure depicted as 4a. The presence of a hydroxyl group at C-26 was confirmed by converting 4a into 4b, C\(_{31}\)H\(_{48}\)O\(_7\) (M\(^{+} \)=532.3392), by treating with NaBH\(_4\) and following by CuSO\(_4\)/acetone. Thus, the structure of methyl lucidenate G was determined to be methyl 3\( \beta \),15\( \alpha \)-dihydroxy-4\( \beta \)-hydroxymethyl-4\( \alpha \),14\( \alpha \)-dimethyl-3,11-dioxo-5\( \alpha \)-chol-8-ene-24-oate (4a).

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REFERENCES

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