Structural Elucidation of New Diterpenoids isolated from *Rabdosia umbrosa* var. *leucantha* f. *Kameba*

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Four new *ent*-kaurenoids, kamebakaurin, kamebakaurinin, kamebacetal A, and kamebacetal B have been isolated from *Rabdosia umbrosa* var. *leucantha* f. *Kameba*. Their structures have been established on the basis of spectroscopic and chemical evidence.

Many plants of the genus *Rabdosia*,† are very bitter and over 100 diterpenoids having structures derived biosynthetically from *ent*-kaurene have been isolated [1] as the bitter principles; some of these also showed biological activity,[2] *e.g.* antibacterial and antitumour, *etc.* From *R. umbrosa* var. *leucantha* f. *Kameba*., mebadonin,[3] isodomedin,[4] kamebanin (**2**),[5] and leukamenin A-F [6] were isolated and their structures were determined. In the course of our studies on bitter principles of *R. umbrosa* var. *leucantha* f. *Kameba* (Labiatae), four new diterpenoids together with known kamebanin (**2**) were isolated. In this paper, we describe the isolation and structural elucidation of these new diterpenoids.

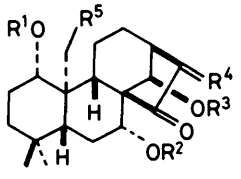
Dried leaves of *R. umbrosa* var. *leucantha* f. *Kameba*, collected in Miyagi prefecture (Japan), were extracted with methanol. The methanolic extract was fractionated as described in the Experimental section. The ethyl acetate-soluble fraction was recrystallized from methanol, after washing with ether, to give kamebakaurin (**1**). The ether washing was separated by repeated column chromatography on silica gel to give kamebacetal A (**18**) (0.019%), kamebacetal B (**24**) (0.008%), kamebakaurin (**1**) (total 0.126%), kamebakaurinin (**13**) (0.0026%), and the known kamebanin (**2**) (0.018%).

Kamebakaurin (**1**), m.p. 232—234 °C, $[\alpha]_D$ −107° (MeOH), was assigned the molecular formula $C_{20}H_{30}O_5$ on the basis of its elemental analysis and mass spectrum. The presence of a five membered ring ketone conjugated with an α-methylene group in (**1**) is indicated by the following spectral data: $\lambda_{max.}$ 233 nm (MeOH) (ε 7 700); $\nu_{max.}$ 1 720 and 1 650 cm^{-1}; $\delta_H(C_5D_5N)$ 6.24 (1 H, br, s) and 5.30 (1 H, br s); $\delta_C(C_5D_5N)$ 115.3 (t), 150.8 (s) (>C=CH_2) and 209.3 (s) (ketone). Compound (**1**) also shows a strong absorption (3 400 cm^{-1}) due to hydroxy groups in its i.r. spectrum. The following facts indicate the presence of four hydroxy groups in (**1**): four proton signals at δ_H 7.87, 7.39, 6.80 and 5.43 in the ^1H n.m.r. spectrum were removed on addition of D_2O; four signals assigned to carbons bearing an oxygen atom [$\delta(C_5D_5N)$ 81.3(d), 76.5(d), 74.8(d), and 61.9(t)] were observed in the ^{13}C n.m.r. spectrum (see Table); on acetylation with acetic anhydride–pyridine, compound (**1**) gave the tetra-acetate (**3**), m.p. 182—184 °C, [δ_H 2.28, 2.05 (each 3 H, s) and 2.00 (6 H, s)]. From the molecular formula and the properties of the oxygen atoms, compound (**1**) is a member of tetracyclic diterpenoid family. From the above-mentioned partial structure and a consideration of the structures of diterpenoids isolated so far from plants of the *Rabdosia* species it seemed likely that kamebakaurin (**1**) has *ent*-15-oxokaur-16-ene (**10**) as its basic skeleton. This was supported by the fact that the dihydro derivative (**4**), m.p. 284—286 °C, derived from compound (**1**) by catalytic hydrogenation showed a negative Cotton effect in its

Table. ^{13}C N.m.r. data[a] for kamebakaurin (**1**) and kamebakaurinin (**13**)

Carbon	(1)	(13)
1	81.3	34.7
2	30.7	19.0
3	39.0	41.9
4	32.9	33.3
5	52.2	53.8
6	30.3	30.0
7	74.8	75.4
8	62.1	60.1
9	56.8	67.0
10	47.9	44.0
11	21.5	65.4
12	31.5	39.8
13	48.1	47.1
14	76.5	77.5
15	209.3	207.7
16	150.8	151.8
17	115.3	113.3
18	33.3	34.2
19	22.3	22.9
20	61.9	60.3

[a] Measured for C_5D_5N solution.



(**1**) $R^1 = R^2 = R^3 = H$, $R^4 = CH_2$, $R^5 = OH$
(**2**) $R^1 = R^2 = R^3 = H$, $R^4 = CH_2$, $R^5 = H$
(**3**) $R^1 = R^2 = R^3 = Ac$, $R^4 = CH_2$, $R^5 = OAc$
(**4**) $R^1 = R^2 = R^3 = H$, $R^4 = \alpha$-H, β-Me, $R^5 = OH$
(**5**) $R^1 = H$, R^2, R^3 > CMe_2, $R^4 = CH_2$, $R^5 = OH$
(**6**) $R^1 = R^2 = R^3 = Ac$, $R^4 = CH_2$, $R^5 = OH$
(**7**) $R^1 = R^2 = R^3 = Ac$, $R^4 = \alpha$-H, β-Me, $R^5 = OH$
(**8**) $R^1 = H$, R^2, R^3 > CMe_2, $R^4 = \alpha$-H, β-Me, $R^5 = OH$
(**9**) R^1, R^5 > $-O-CMe_2$, R^2, R^3 > CMe_2, $R^4 = \alpha$-H, β-Me

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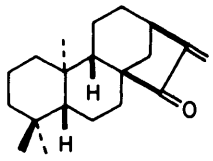
† The taxon of this genus was previously recognized as Isodon (H. Hara, *Jpn. J. Bot.*, 1972, **47**, 193).



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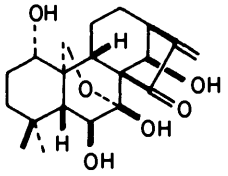

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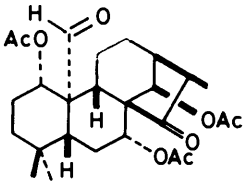
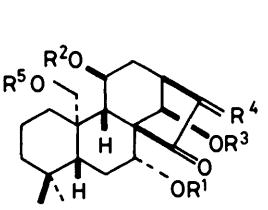
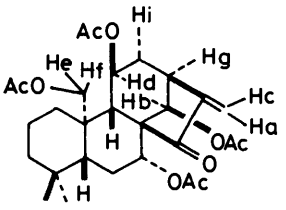


(12)

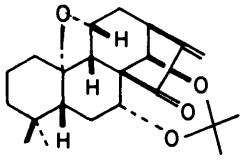
o.r.d. spectrum.[7] Thus, kamebakaurin has a structure in which four hydroxy groups are introduced into the basic skeleton (**10**). The location of those were elucidated as follows. In the ^{1}H n.m.r. spectrum of compound (**1**), the signals [$\delta_H(C_5D_5N)$ 5.57 (1 H, d, *J* 1.5 Hz), 4.85 (1 H, dd, *J* 9 and 9 Hz), 4.62 (1 H, d, *J* 12 Hz), 4.30 (1 H, dd, *J* 12 and 8 Hz, changed to a doublet, *J* 12 Hz, on addition of D_2O), and 3.54 (1 H, dd, *J* 10 and 6 Hz)] were assigned to the protons on carbons bearing a hydroxy group. The chemical shift and coupling pattern of the signal at δ 5.57 is very similar to that of 14α-H [$\delta(C_5D_5N)$ 5.35, s] of oridonin (**11**).[8] The similarity was well explained by placing a hydroxy group at C-14β in the structure of kamebakaurin since the 14α-proton will suffer an anisotropic effect from the carbonyl group at C-15 and has a dihedral angle of *ca.* 90° to 13-H. From their multiplicity, the signals at δ 4.85 and 3.45 are assigned to axial hydrogens attached to carbons neighbouring a methylene group and a tetrasubstituted carbon. This indicates the presence of α-equatorial hydroxy groups at two of three possible positions (*i.e.* C-1, -3, and -7) in compound (**1**). The hydrogen (δ 4.85) is also deshielded strongly like the hydrogen at C-14α. Such is the position of the axial 7β-H that it is likely to experience an anisotropic effect from the carbonyl group at C-15. The presence of a hydroxy group at C-7α was confirmed by the formation of the monoacetonide (**5**), m.p. 189—191 °C [$\delta_H(C_5D_5N)$ 5.28 (br s), 4.58 (dd, *J* 12 and 8 Hz) and 1.70 and 1.38 (each 3 H, s)] in which the hydroxy group at C-14β took part in an acetonide ring formation. On the other hand, the signals at δ 4.62 and 4.30 indicate the presence of a hydroxymethyl group located on a tetrasubstituted carbon. On acetylation with acetic anhydride–pyridine, compound (**1**) gave the triacetate (**6**), m.p. 203—205.5 °C [$\nu_{max.}$ 3 550 and 3 400 cm^{-1}; δ_H 4.46 (d, *J* 12 Hz) and 4.24 (d, *J* 12 Hz)], together with the above mentioned tetra-acetate (**3**). Since the hydroxymethyl group is not acetylated in compound (**6**), the presence of a fourth hydroxy group at C-20 is indicated, the steric hindrance of this position being greater than that at C-18 and C-19. The presence of a hydroxymethyl group at C-10 was confirmed as follows. The dihydrokamebakaurin triacetate (**7**), m.p. 206—208 °C, obtained by acetylation of compound (**4**), was subjected to Jones oxidation to give the aldehyde (**12**), m.p. 186.5—188 °C [δ_H 10.58 (d, *J* 2 Hz, CHO) and 5.64 (d, *J* 2 Hz, 14α-H)]. In the ^{1}H n.m.r. spectrum of compound (**12**), a nuclear Overhauser enhancement (n.O.e.) (16%) was observed for the aldehyde proton on irradiation at the frequency of 14α-H. The remaining signal (δ 3.54) is due to a proton at C-1β or C-3β. With the remaining secondary alcohol group located at C-1α, formation of an acetonide between 1α-OH and 20-OH is possible. Treatment of compound (**4**) in dimethylformamide with 2,2-dimethoxypropane in the presence of catalytic amount of toluene-*p*-sulphonic acid gave the diacetonide (**9**), m.p. 157—158 °C [δ_H 1.53, 1.45, 1.35, and 1.26 (each 3 H, s)] together with the monoacetonide (**8**) [δ_H 1.58 and 1.27 (each 3 H, s)]. The location of the α-equatorial acetoxy group at C-1 in compound (**12**) was further supported by collapse of the aldehyde signal to a singlet on irradiation at δ_H 4.56 (1-H): this arose from suppression of the coupling due to W interaction. On the basis of these findings, we propose structure (**1**), *ent*-1β, 7β, 14α, 20-tetrahydroxykaur-16-en-15-one, for kamebakaurin.





(**13**) $R^1 = R^2 = R^3 = R^5 = H$, $R^4 = CH_2$ (**14**)
(**14**) $R^1 = R^2 = R^3 = R^5 = Ac$, $R^4 = CH_2$
(**15**) $R^1 = R^2 = R^3 = R^5 = H$, R^4 = α-H, β-Me
(**16**) $R^1 = R^3 = R^5 = H$, $R^2 = Ac$, $R^4 = CH_2$

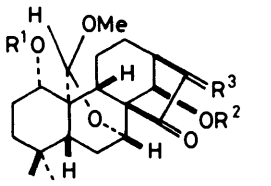
Kamebakaurinin (**13**), m.p. 267—269 °C, $[\alpha]_D$-101° (pyridine) has the same molecular formula, $C_{20}H_{30}O_5$ (chemical ionization mass spectrum in isobutane and elemental analysis) as kamebakaurin (**1**) and the following spectroscopic results support a partial structure containing a five-membered ring containing a ketone conjugated with an α-methylene group: $\lambda_{max.}$(MeOH) 238 nm (ε 5 700); $\nu_{max.}$ 1 720 and 1 650 cm^{-1}; $\delta_H(C_5D_5N)$ 6.27 (1 H, br s) and 5.38 (1 H, br s); $\delta_C(C_5D_5N)$ 113.3 (t) and 151.8 (s) (>C=CH_2), and 207.7 (s) ketone). The presence of four hydroxy groups in the structure of compound (**13**) was suggested by disappearance of four proton signals in the ^{1}H n.m.r. spectrum on addition of D_2O: signals due to oxygen-bearing carbons were also observed at δ 77.5 (d), 75.4 (d), 65.4 (d), and 60.3 (t) in the ^{13}C n.m.r. spectrum (see Table). Compound (**13**) on acetylation with acetic anhydride–pyridine, gave the tetra-acetate (**14**), m.p. 228—230 °C, [δ_H 2.12, 2.03, 1.93, and 1.83 (each 3 H, s)] and upon catalytic hydrogenation gave the dihydrokamebakaurinin (**15**), m.p. 272—275 °C; this showed a negative Cotton effect in its o.r.d. spectrum. The above evidence suggests that kamebakaurinin (**13**) like kamebakaurin (**1**) also has *ent*-15-oxo-kaur-16-ene (**10**) as a basic skeleton. The location of four hydroxy groups was deduced as follows. In the ^{1}H n.m.r. spectrum of compound (**13**), signals due to three methine protons [$\delta(C_5D_5N)$ 5.62 (1 H, br s), 4.92 (1 H, dd, *J* 11 and 6 Hz), and 4.82 (1 H, br d, *J* 4 Hz)] and signals due to one methylene proton [$\delta_H(C_5D_5N)$ 4.29 (2 H, s)] which are attached to carbons having a hydroxy group were observed. By analogy with kamebakaurin (**1**), the signals at δ 5.62 and 4.92 could be assigned to 14α-H and 7β-H, respectively. Thus, two of the four hydroxy groups could be located at C-14β and C-7α. This was confirmed by formation of an acetonide (**17**), m.p. 150—153 °C, [δ_H 1.76 and 1.23 (each 3 H, s)] (discussed later). The signal at δ 4.29 was attributed to the methylene of a hydroxymethyl group which could be present at one of three possible positions, *i.e.* C-18, -19, and -20.



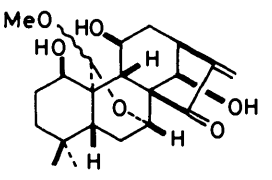
(17)

Furthermore, the signal at δ 4.82 indicates the presence of a further secondary hydroxy group in compound (**13**). The configuration of this secondary group is axial as judged by its coupling constant. The location of these hydroxy groups were examined with INDOR[9] and n.O.e. experiments for kamebakaurinin tetra-acetate (**14**). On monitoring the signals at δ 6.04 (H_a) and 5.34(H_c) in turn, INDOR signals were observed for the signals of H_c. H_g, and H_a, H_g, respectively. Therefore, H_a and H_c are assigned to protons at C-17 and H_g (δ 3.01) to 13-H. On monitoring the signal at δ 5.71 (H_b), an INDOR signal was observed for the signal of H_g. Thus, H_b is assigned to 14α-H. On the other hand, on monitoring the signals at δ 5.05 (H_e) and 4.40 (H_f) in turn, INDOR signals due to geminal coupling were observed for H_f and H_e, respectively. This confirms that H_e and H_f are methylene protons of an acetoxymethyl group. Irradiation at the frequencies of H_f and H_b, resulted in n.O.e.s (10.9 and 8.3%) being observed for H_b and H_f, respectively. These findings indicate that a hydroxymethyl group is located at C-10 in kamebakaurinin (**13**). A proton attached to a carbon bearing a secondary axial acetoxy group was observed at δ 5.19 (H_d) and coupled with H_i (δ_H 2.70, ddd, *J* 14, 4 and 4 Hz). Based on an examination of Dreiding models and consideration of its multiplicity, H_i could be attributed to an axial H at C-12 ($J_{12ax,12eq}$ 14, $J_{12ax,13}$ 4, $J_{12ax,11eq}$ 4, and $J_{12eq,11eq}$ $J_{11eq,9} = 0$ Hz). Therefore, the remaining axial hydroxy group in (**13**) is considered to be located at C-11 and β-orientated. The treatment of kamebakaurinin (**13**) with 2,2-dimethoxypropane in the presence of catalytic amount of toluene-*p*-sulphonic acid in acetone gave the above mentioned anhydro-acetonide (**17**), a compound which showed no hydroxy group absorption in its i.r. spectrum. In its ^{1}H n.m.r. spectrum, there were signals due to methylene protons at C-20 at δ 3.80 and 3.67 (*J* 9 Hz) and a signal at δ 4.13 (t, *J* 6 Hz) attributable to a proton attached to a carbon bearing an ether oxygen. The latter signal is assignable to 11β-H the dihedral angles of which to 9-H, 12ax-H, 12eq-H are *ca.* 30°, 30°, and 90°, respectively. During acetonide formation between 7α-OH and 14β-OH, a five-membered ether could be formed *via* elimination of a hydroxy group at C-11 by an addition of H^+ and a simultaneous attack from behind of a hydroxy group at C-20. The above facts suggest *ent*-7β, 11α, 14α, 20-tetrahydroxykaur-16-en-15-one as the structure for kamebakaurinin. The structure corresponds to a deacetyl derivative of rastronol F(**16**)[10] isolated from *Englerastrum scandens* Alston (Labiatae). In fact, kamebakaurinin tetra-acetate (**14**) was identical with an authentic specimen of rastronol F triacetate, a finding which confirms kamebakaurinin as having structure (**13**).

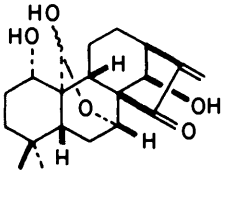
Kamebacetal A(**18**), m.p. 253—256 °C, $[\alpha]_D$ −40° (MeOH) has the molecular formula, $C_{21}H_{30}O_5$ assigned on the basis of elemental analysis and mass spectrum. Once again spectroscopic evidence showed the presence of a five membered-ring ketone conjugated with an α-methylene group together with a methoxy group: $\lambda_{max.}$(MeOH) 233.5 nm (ε 8 780); $\nu_{max.}$ 1 705 and 1 645 cm^{-1}; δ_H (C_5D_5N) 6.18 (1 H, br s), 5.36 (1 H, br s), and 3.36 (3 H, s); δ_C (C_5D_5N) 115.5 (dd), 154.4 (s) (>C=CH_2), 206.4 (s) (ketone), and 54.9 (q) (OMe). Catalytic hydrogenation of compound (**18**) gave a dihydro derivative (**19**), m.p. 200—202 °C, which showed a negative Cotton effect in its o.r.d. spectrum. These data suggest *ent*-15-oxokaur-16-ene(**10**) as a basic skeleton for kamebacetal A. The ^{1}H n.m.r. spectrum of compound (**18**) further showed two signals [δ_H 5.46 (d, *J* 1 Hz) and 5.10 (d, *J* 1.5 Hz)] in addition to the lower field signals. One of them is assigned to 14α-H by analogy with the signals of kamebakaurin (**1**) and kamebakaurinin (**13**). The other is considered to be attributable to an anomeric proton by its chemical shift and the presence of a methoxy group in (**18**). It was supported by the presence of anomeric carbon [δ 102.1 (d)] in the ^{13}C n.m.r. spectrum of (**18**). There was one further signal [δ_H 4.70 (dd, *J* 4 and 2 Hz)] in addition to those described above and this did not show a downfield shift in the diacetate (**20**). It was, therefore, assignable to a proton attached to a carbon bearing an acetalic oxygen. Signals due to a hydroxymethyl group found in kamebakaurin (**1**) and kamebakaurinin (**13**) were not observed in the ^{1}H n.m.r. spectrum of (**18**). Thus, it was assumed that a hydroxymethyl group at C-10 had been oxidized to an aldehyde and formed an acetal with a hydroxy group. Rastronol E acetal (**21**)[10] showed a signal for 7-H in the ^{1}H n.m.r. spectrum at δ 4.68 (d, *J* 4 Hz) which is very similar to the signal at δ 4.70 in (**18**). From these considerations, we presumed an acetal linkage between C-20 and C-7. With four oxygen atoms characterized and from the degree of unsaturation of (**18**), the remaining one is attributable to a hydroxy group. In the ^{1}H n.m.r. spectrum of the diacetate (**20**), signals at δ 4.68 (dd, *J* 9 and 7 Hz) and δ 6.04 (14α-H) were observed. From its chemical shift and coupling constant the former is very similar to that of 1β-H in the ^{1}H n.m.r. spectrum of kamebakaurin triacetate (**6**) [δ_H 4.63 (dd, *J* 7 and 7 Hz)]; this indicates that kamebacetal A has an α-orientated secondary hydroxy group at C-1. On the basis of these findings, kamebacetal A should be represented as (**18**) or its epimer at C-20. Hydrolysis of kamebacetal A with oxalic acid in aqueous tetrahydrofuran followed by Jones oxidation gave a δ-lactone (**23**), m.p. 265—268 °C ($\nu_{max.}$ 1 708 cm^{-1}), which is identical with that obtained by Jones oxidation of kamebakaurin (**1**). The location of the oxygen functions as in (**18**) is, therefore, supported by chemical evidence. Further, INDOR experiments for (**18**) revealed the stereochemistry at C-20 as follows. On monitoring the signal (δ_H 5.46), INDOR signals due to n.O.e. appeared at the signals of the methoxy and one (δ_H 0.93) of the dimethyl groups at C-4. Thus, the signal at δ_H 5.46 was assigned to an anomeric proton and the stereochemistry at C-20 is shown as *S*.



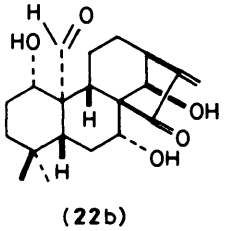
(**18**) $R^1 = R^2 = H$, $R^3 = CH_2$
(**19**) $R^1 = R^2 = H$, R^3 = α-H, β-Me
(**20**) $R^1 = R^2 = Ac$, $R^3 = CH_2$



(**21**)



(**22a**)



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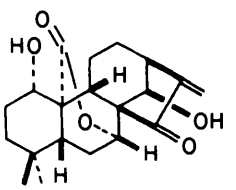

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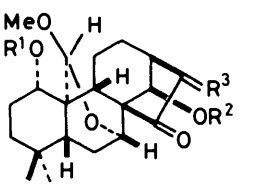

(**24**) $R^1 = R^2 = H$, $R^3 = CH_2$
(**25**) $R^1 = R^2 = H$, R^3 = α-H, β-Me
(**26**) $R^1 = R^2 = H$, R^3 = α-Me, β-H
(**27**) $R^1 = R^2 = Ac$, $R^3 = CH_2$

Kamebacetal B (**24**), m.p. 230—232 °C, $[\alpha]_D$ −58° (MeOH), has the same molecular formula, $C_{21}H_{30}O_5$ as kamebacetal A (**18**) (elemental analysis and mass spectrum). The physical and spectral data of (**24**) and its derivatives, dihydrokamebacetal B(**25**) + (**26**) and diacetate (**27**), are very similar to those of (**18**) and its derivatives. This suggests that kamebacetal B has a structure corresponding to the C-20 epimer of kamebacetal A (**18**). Hydrolysis of (**24**) with oxalic acid in aqueous tetrahydrofuran, followed by Jones oxidation gave a δ-lactone (**23**) which was identical with the δ-lactone derived from (**18**). Thus, the structure of kamebacetal B is determined as (**24**). The stereochemistry at C-20 in (**24**) is shown as *R*.

It is possible that kamebacetal A (**18**) and B (**24**) exist as their demethyl derivatives (**22**) in the plant, since (**18**) and (**24**) could be formed from (**22**) during the extraction procedure.

Experimental

M.p.s were taken on a Yanagimoto melting point apparatus and are uncorrected. I.r. spectra were recorded on a Hitachi EPI-510 spectrometer, using KBr disks unless otherwise stated. Further, unless otherwise stated, ^{1}H n.m.r. spectra were taken with JEOL PS 100 or Hitachi R-22 spectrometers for solutions in deuteriochloroform and ^{13}C n.m.r. were taken with a JEOL JNM FX 200 spectrometer for solutions in [$^2H_5$]pyridine. Tetramethylsilane was used as internal standard and chemical shifts are given in δ (p.p.m.). Mass spectra were determined with JEOL 01SG or JMS D-300 spectrometers. U.v. spectra were recorded with a Hitachi type 124 double-beam spectrometer for solutions in methanol. Optical rotations were measured with a Yanagimoto OR 50 or a Union PM-201 polarimeter. O.r.d. were taken with a JASCO Model ORD/UV-5 spectrophotometer. Kieselgel 60 (0.063—0.200 mm, Merck) was used for chromatography, and pre-coated silica gel plates F_{254} (0.25 and 0.5 mm in thickness) were used for t.l.c. Extracts were dried over anhydrous sodium sulphate or magnesium sulphate.

Isolation of Diterpenoids from Rabdosia umbrosa var. leucantha f. Kameba.—Dried leaves of *R. umbrosa* var. *leucantha* f. *Kameba* (9.6 kg), which were collected in Miyagi prefecture, Japan in autumn 1977, were extracted with boiling methanol, and the extract was concentrated to 17 l. Insoluble material was filtered off, and the filtrate was partitioned with n-hexane (17 l). The aqueous methanolic layer was concentrated under reduced pressure to *ca.* 3 l and water (2 l) was added. The suspension was extracted with ethyl acetate (5 l). After being washed with water, the ethyl acetate extract was concentrated under reduced pressure to give a syrupy residue (360 g) which was washed with ether to give a residue (99 g). The methanolic solution of the residue was treated with active charcoal and recrystallized from methanol to give kamabakaurin (**1**) (10.35 g). The ether washings were concentrated under reduced pressure to give a syrup (195 g) which was chromatographed on silica gel (2.0 kg) column with methylene dichloride–acetone (increasing acetone content) as eluant. Fractions (I—V) were obtained from elution of 5—10%, 10%, 15—20%, 25—30%, and 40—60% acetone content, respectively. Fraction I (10.0 g) was recrystallized from methanol with active charcoal treatment to give kamebacetal A (**18**) (0.86 g) as colourless needles. Fraction II (4.8 g) was rechromatographed on silica gel (100 g) with methylene dichloride–acetone (increasing acetone content) as eluant. The eluate (3.54 g) from 10% acetone–methylene dichloride was recrystallized from methanol with active charcoal treatment to give kamebacetal A (**18**) (0.97 g) (total 1.83 g, yield 0.019%). The mother liquor (3.98 g) from fraction I after kamebacetal A (**18**) had crystallised was rechromatographed on silica gel (100 g) with methylene dichloride–acetone (increasing acetone content) as eluant. The eluate from 10—20% acetone–methylene dichloride afforded kamebacetal B (**24**) (0.72 g). The mother liquor (0.156 g) of fraction II after kamebacetal A had crystallised, was purified by preparative t.l.c. (SiO_2; 20% acetone–methylene dichloride) to give kamebacetal B (**24**) (0.05 g) (total 0.77 g, yield 0.008%). Fraction III (12.0 g) was recrystallized from methanol with active charcoal treatment to give kamebanin (**2**) (1.7 g) (yield 0.018%). Fraction IV (19.2 g) was recrystallized from methanol with active charcoal treatment to give kamebakaurin (**1**) (1.76 g) (total 12.11 g, yield 0.126%). After treatment with active charcoal, fraction V (13.0 g) was rechromatographed on silica gel (400 g) with chloroform–methanol (increasing methanol content) as eluant. The eluate (5.40 g) from 10% methanol–chloroform was recrystallized from methylene dichloride–methanol to give kamebakaurinin (**13**) (0.25 g) (yield 0.0026%). The physical properties of the isolated diterpenoids are as follows.

Kamebakaurin (**1**), colourless needles (from methanol), m.p. 232—234 °C, $[\alpha]_D^{21.5}$ −107° (*c* 1.0 in MeOH); $\lambda_{max.}$ (MeOH) 233 nm (ε 7 700); $\nu_{max.}$ 3 400, 1 720, and 1 650 cm^{-1}; δ_H (C_5D_5N) 7.87 (1 H, m, OH), 7.39 (1 H, m, OH), 6.80 (1 H, br d, *J* 4 Hz, OH), 6.24 (1 H, br s, 17-H), 5.57 (1 H, d, *J* 1.5 Hz, 14-H), 5.43 (1 H, br d, *J* 7 Hz, OH), 5.30 (1 H, br s, 17-H), 4.85 (1 H, dd, *J* 9 and 9 Hz, 7-H), 4.62 (1 H, d, *J* 12 Hz, 20-H), 4.30 (1 H, dd, *J* 12 and 8 Hz, changed to doublet on addition of D_2O, *J* 12 Hz, 20-H), 3.54 (1 H, dd, *J* 10 and 6 Hz, 1-H), and 0.90 and 0.80 (each 3 H, s, 4-Me_2); ^{13}C n.m.r. see Table; *m/z* 350 (M^+) (Found: C, 68.6; H, 8.8. $C_{20}H_{30}O_5$ requires C, 68.54; H, 8.63%).

Kamebakaurinin (**13**), colourless needles, m.p. 267—269 °C (from methylene dichloride–methanol), $[\alpha]_D^{25}$ −101° (*c* 0.92 in pyridine); $\lambda_{max.}$ (MeOH) 238 nm (ε 5 700); $\nu_{max.}$ 3 300, 3 200, 1 720, and 1 650 cm^{-1}; δ_H (C_5D_5N) 8.08 (1 H, m, OH), 7.44 (1 H, m, OH) 6.27 (1 H, br s, 17-H), 6.13 (1 H, m, OH), 5.62 (1 H, br s, 14-H) 5.52 (1 H, m, OH), 5.38 (1 H, br s, 17-H), 4.92 (1 H, dd, *J* 11 and 6 Hz, 7-H), 4.82 (1 H, br d, *J* 4 Hz, 11-H), 4.29 (2 H, s, 20-H_2), and 0.84 and 0.82 (each 3 H, s, 4-Me_2); ^{13}C n.m.r. see Table *m/z* 350 (M^+) (c.i., isobutane) (Found: C, 68.8; H, 8.9. $C_{20}H_{30}O_5$ requires C, 68.54; H, 8.63%).

Kamebanin (**2**), colourless plates, m.p. 264—265.5 °C (from MeOH), $[\alpha]_D^{24}$ −89° (*c* 1.0 in MeOH); $\lambda_{max.}$ (MeOH) 232 nm (ε 8 500); $\nu_{max.}$ 3 200, 1 730, and 1 650 cm^{-1}; δ_H (C_5D_5N) 8.04 (1 H, m, OH), 7.36 (1 H, m, OH), 6.25 (1 H, br s, 17-H), 5.88 (1 H, m, OH), 5.29 (1 H, br s), 5.22 (1 H, br s), 4.70 (1 H, dd, *J* 10 and 6 Hz, 7-H), 1.40 (3 H, s, 10-Me), and 0.84 and 0.80 (each 3 H, s, 4-Me_2); δ_H (C_5D_5N–$CDCl_3$) 6.13 (1 H, br s, 17-H), 5.24 (1 H, br s, 17-H), 5.06 (1 H, br s, 14-H), 4.48 (1 H, dd, *J* 11 and 5 Hz, 7-H), 3.36 (2 H, m), 3.15 (1 H, m, 13-H), 1.30 (3 H, s, 10-Me), and 0.82 (6 H, s, 4-Me_2) (Found: M^+, 334.2136. $C_{20}H_{30}O_4$ requires *M*, 334.2145). This compound was identified by comparison with the reported physical data of kamebanin.

Kamebacetal A (**18**), colourless needles, m.p. 253—256 °C, $[\alpha]_D^{19}$ −40° (*c* 1.1 in MeOH); $\lambda_{max.}$ (MeOH) 233.5 nm (ε 8 780); $\nu_{max.}$ 3 450, 1 705, and 1 645 cm^{-1}; δ_H (C_5D_5N) 6.18 (1 H, br s, 17-H), 5.46 (1 H, d, *J* 1 Hz, 20-H), 5.36 (1 H, br s, 17-H), 5.10 (1 H, d, *J* 1.5 Hz, 14-H), 4.95 (1 H, m, OH), 4.70 (1 H, dd, *J* 4 and 2 Hz, 7-H), 4.39 (1 H, d, *J* 8 Hz, OH), 3.36 (3 H, s, OMe), and 0.93 and 0.76 (each 3 H, s, 4-Me_2); δ_C(C_5D_5N) 206.4 (s), 154.4 (s), 115.5 (dd), 102.1 (d), 76.1 (d), 70.5 (d), 67.1 (d), 58.6 (s), 54.9 (q), 51.2 (d), 48.8 (d), 44.0 (s), 43.7 (d), 39.2 (t), 34.1 (s), 32.3 (t), 32.1 (q), 30.8 (t), 25.7 (dd), 23.5 (t), and 20.7 (q); *m/z* 330 ($M - CH_3OH$)$^+$ (Found: C, 69.3; H, 8.2. $C_{21}H_{30}O_5$ requires C, 69.58 H, 8.34%).

Kamebacetal B (**24**), colourless needles, m.p. 230—232 °C, $[\alpha]_D^{26}$ −58° (*c* 0.43 in MeOH); $\lambda_{max.}$(MeOH) 229 nm (ε 8 780); $\nu_{max.}$ 3 430, 1 700, and 1 640 cm^{-1}; δ_H (C_5D_5N) 6.23 (1 H, br s, 17-H), 5.48 (1 H, s, 20-H), 5.40 (1 H, br s, 17-H), 4.96 (1 H, d, *J* 1.5 Hz, 14-H), 4.79 (1 H, t, *J* 3 Hz, 7-H), 3.46 (3 H, s, OMe), 3.19 (1 H, br d, *J* 10 Hz, 13-H), and 1.23 and 0.99 (each 3 H, s, 4-

Me_2); *m/z* 362 (M^+) (Found: C, 69.7; H, 8.6. $C_{21}H_{30}O_5$ requires C, 69.58; H, 8.34%).

Kamebakaurin Triacetate (**6**) *and Tetra-acetate* (**3**).—Kamebakaurin (**1**) (239 mg) dissolved in acetic anhydride–pyridine (1:1; 12 ml) was kept for 31 h at 5 °C. Methanol was added to decompose the excess of reagent, and the solvent was evaporated under reduced pressure. A suspension of the residue in 1% hydrochloric acid was extracted with chloroform (15 ml × 2, 10 ml). The chloroform extract was washed with water, dried, and evaporated under reduced pressure to give a residue (324 mg), which was separated on silica gel plates (solvent: 6% acetone–methylene dichloride, developed twice) to give the tetra-acetate (**3**) (87 mg) from the faster-moving zone and the triacetate (**6**) (108 mg) from the slower-moving zone. Both acetates were recrystallized from methanol.

Triacetate (**6**), m.p. 203—205.5 °C; $\lambda_{max.}$ 233 nm (ε 7 906); $\nu_{max.}$ 3 550, 3 400br, 1 735br, 1 650, and 1 250br cm^{-1}; δ_H 6.06 (1 H, br s, 17-H), 5.97 (1 H, br s, 14-H), 5.33 (1 H, br s, 17-H), 4.63 (1 H, dd, *J* 7 and 7 Hz, 1-H), 4.46 and 4.24 (each 1 H, ABd, *J* 12 Hz, 20-H_2), 3.06 (1 H, m, 13-H), 2.04 (6 H, s, Ac_2), 1.92 (3 H, s, Ac), and 0.90 and 0.86 (each 3 H, s, 4-Me_2); *m/z* 458 ($M - CH_3CO_2H)^+$ (Found: C, 65.3; H, 7.7. $C_{26}H_{36}O_8$ requires C, 65.53; H, 7.61%).

Tetra-acetate (**3**), m.p. 182—184 °C; $\lambda_{max.}$ 233.5 nm (ε 8 506); $\nu_{max.}$ 1 740, 1 650, and 1 230—1 250 cm^{-1}; δ_H 6.12 (1 H, br s, 17-H), 5.99 (1 H, br s, 14-H), 5.40 (1 H, br s, 17-H), 5.20 (1 H, dd, *J* 10 and 5 Hz, 7-H), 4.82 and 4.63 (each 1 H, ABd, *J* 13 Hz, 20-H_2), 3.11 (1 H, m, 13-H), 2.28 and 2.05 (each 3 H, s, Ac_2), 2.00 (6 H, s, Ac_2), and 0.95 and 0.91 (each 3 H, s, 4-Me_2) [Found: $(M - CH_3COOH)^+$, 458.2301. $C_{26}H_{34}O_7$ requires *M*, 458.2305].

Dihydrokamebakaurin (**4**).—Platinum oxide (5 mg) was added to a solution of kamebakaurin (**1**) (300 mg) in methanol (10 ml), and the mixture was stirred for 30 min under an atmosphere of hydrogen. The catalyst was filtered off and the filtrate was evaporated under reduced pressure to give a residue (291 mg) which was purified by column chromatography (silica gel 8 g; 10% acetone–chloroform) to afford dihydrokamebakaurin (**4**) (243 mg). This recrystallized from methanol as colourless needles, m.p. 284—286 °C; $\nu_{max.}$ 3 300, 1 715, and 1 060 cm^{-1}; δ_H (C_5D_5N) 7.60 (1 H, m, OH), 7.32 (1 H, m, OH), 6.80 (1 H, m, OH), 5.63 (1 H, br s, 14-H), 5.28 (1 H, d, *J* 8 Hz, OH), 4.60 (1 H, d, *J* 12 Hz, 20-H), 4.27 (1 H, dd, *J* 12 and 8 Hz, changed to doublet on addition of D_2O, *J* 12 Hz, 20-H), 3.56 (1 H, m, changed to dd on addition of D_2O, *J* 9 and 6 Hz, 1-H), 1.22 (3 H, d, *J* 7 Hz, 16-Me), and 0.85 and 0.79 (each 3 H, s, 4-Me_2); o.r.d. $\lambda_{max.}$ (MeOH) nm (φ): 320 (−3 695) and 287 (1 253) (Found: C, 68.2; H, 9.3. $C_{20}H_{32}O_5$ requires C, 68.15; H, 9.15%).

Kamebakaurin Monoacetonide (**5**).—Concentrated sulphuric acid (one drop) was added to a solution of kamebakaurin (**1**) (100 mg) in anhydrous acetone (12 ml) and the mixture was stirred for 14 days at room temperature. Further concentrated sulphuric acid (one drop) was added during this period. After neutralization with saturated aqueous sodium hydrogen carbonate, the mixture was diluted with water (20 ml) and extracted with chloroform (20 ml × 2). The chloroform extract was washed with water, dried, and evaporated to give a residue (120 mg) which was purified by column chromatography (silica gel 3 g; 1% acetone–methylene dichloride) to give the monoacetonide (**5**) (50.4 mg). Recrystallization from methanol gave colourless needles (16.8 mg), m.p. 189—191 °C; $\lambda_{max.}$ 233.5 nm (ε 8 040); $\nu_{max.}$ 3 400, 1 720, and 1 650 cm^{-1}; δ_H 6.10 (1 H, br s, 17-H), 5.32 (1 H, br s, 17-H), 4.63 (1 H, d, *J* 2 Hz, 14-H), 4.42 (1 H, d, *J* 12 Hz, 20-H), 4.22 (1 H, dd, *J* 12 and 7 Hz, 7-H), 3.94 (1 H, dd, *J* 12 and 4 Hz, changed to d on addition of D_2O, *J* 12 Hz, 20-H), 3.55 (1 H, dd, *J* 10 and 4 Hz, 1-H, this signal was superimposed on a hydroxy signal), 3.07 (1 H, m, 13-H), 1.57 and 1.23 (each 3 H, s, acetonide Me_2), and 0.90 and 0.85 (each 3 H, s, 4-Me_2); δ_H (C_5D_5N) 6.66 (1 H, m, OH), 6.22 (1 H, br s, 17-H), 5.70 (1 H, m, OH), 5.28 (2 H, br s, 17-H and 14-H), 4.61 (1 H, d, *J* 12 Hz, 20-H), 4.58 (1 H, dd, *J* 12 and 8 Hz, 7-H), 4.36 (1 H, br d, *J* 12 Hz, 20-H), 3.14 (1 H, m, 13-H), 1.70 and 1.38 (each 3 H, s, acetonide Me_2), 1.01 and 0.83 (each 3 H, s, 4-Me_2) (Found: C, 70.5; H, 8.8. $C_{23}H_{34}O_5$ requires C, 70.74; H, 8.78%).

Dihydrokamebakaurin Triacetate (**7**).—Dihydrokamebakaurin (**4**) (228.5 mg) dissolved in acetic anhydride—pyridine (1:1; 13 ml) was kept for 20 h at room temperature. Work-up as before gave a residue (228.2 mg) which was purified by preparative layer chromatography (SiO_2; 10% acetone–methylene dichloride) to give the dihydro triacetate (**7**) (53 mg); this recrystallized from methanol as colourless needles, m.p. 206—208 °C; $\nu_{max.}$ 3 540, 3 400, 1 735br, and 1 260 cm^{-1}; δ_H 5.97 (1 H, br s, 14-H), 5.14 (1 H, dd, *J* 8 and 8 Hz, 7-H), 4.60 (1 H, dd, *J* 8 and 8 Hz, 1-H), 4.48 and 4.24 (each 1 H, ABd, *J* 14 Hz, 20-H_2), 2.72 (1 H, m, 16-H), 2.05, 2.03, and 1.91 (each 3 H, s, Ac_3), 1.11 (3 H, d, *J* 7 Hz, 16-Me), and 0.90 and 0.85 (each 3 H, s, 4-Me_2); *m/z* 478 (M^+) (Found: C, 65.3; H, 8.1. $C_{26}H_{38}O_8$ requires C, 65.25; H, 8.00%).

Dihydrokamebakaurin Aldehyde Triacetate (**12**).—Jones reagent (0.21 ml) was added to an ice-cooled solution of dihydrokamebakaurin triacetate (**7**) (325 mg) in anhydrous acetone (4 ml) and the mixture was stirred for 5 min at 0 °C. Excess of reagent was decomposed by addition of methanol. After neutralization with 5% aqueous sodium hydrogen carbonate, the resulting precipitate was filtered off and the filtrate was concentrated under reduced pressure. Water (10 ml) was added to the residue which was then extracted with chloroform (10 ml × 4). The chloroform extract was washed with water, dried, and evaporated to give a residue (342 mg) which was recrystallized from methanol to give the aldehyde (**12**), as colourless needles, m.p. 186.5—188 °C; $\nu_{max.}$ 2 740, 1 740br, 1 240br, and 1 040 cm^{-1}; δ_H 10.58 (1 H, d, *J* 2 Hz, 20-H), 5.64 (1 H, d, *J* 2 Hz, 14-H), 5.08 (1 H, dd, *J* 11 and 4 Hz, 7-H), 4.56 (1 H, dd, *J* 7 and 7 Hz, 1-H), 2.76 (1 H, m, 16-H), 2.07 (6 H, s, Ac_2), 1.95 (3 H, s, Ac), 1.10 (3 H, d, *J* 7 Hz, 16-Me), and 0.95 and 0.87 (each 3 H, s, 4-Me_2); *m/z* 476 (M^+) (Found: C, 65.3; H, 7.7. $C_{26}H_{36}O_8$ requires C, 65.53; H, 7.61%).

Dihydrokamebakaurin Monoacetonide (**8**) *and Diacetonide* (**9**).—2,2-Dimethoxypropane (1 ml) and toluene-*p*-sulphonic acid (1 mg) were added to a solution of dihydrokamebakaurin (**4**) (50.2 mg) in dimethylformamide (1 ml) and the mixture was kept for 6.5 h at 80—90 °C. It was then evaporated under reduced pressure and the residue was dissolved in chloroform (15 ml) and the solution washed with 5% aqueous sodium hydrogen carbonate and water, dried, and evaporated to give a residue (64.5 mg). The residue was separated by column chromatography (SiO_2 2 g; methylene dichloride–acetone). The eluate from methylene dichloride gave the diacetonide (**9**) as colourless needles (24.1 mg). The eluate (27.5 mg) from 10% acetone–methylene dichloride was rechromatographed [column chromatography (SiO_2 0.5 g; methylene chloride)] to give the monoacetonide (**8**) as an amorphous powder (21.7 mg).

Monoacetonide (**8**); $\nu_{max.}$ 3 600, 3 500, 1 740, 1 370, and 1 340 cm^{-1}; δ_H 4.65 (1 H, br s, 14-H), 4.38 (1 H, d, *J* 12 Hz, 20-H), 4.06 (1 H, dd, *J* 10 and 10 Hz, 7-H), 3.94 (1 H, br d, changed to a sharp doublet on addition of D_2O, *J* 12 Hz, 20-H), 3.52 (1 H, dd, *J* 10 and 4 Hz, 1-H, this signal was superimposed on a hydroxy signal), 2.89 (1 H, m, 16-H), 1.58 and 1.27 (each 3 H, s, acetonide Me_2), 1.15 (3 H, d, *J* 7 Hz, 16-Me), and 0.87 and 0.82 (each 3 H, s, 4-Me_2) (Found: M^+, 392.2599. $C_{23}H_{36}O_5$ requires *M*, 392.2564).

Diacetonide (**9**), m.p. 157—158 °C; $\nu_{max.}$ 1 750, 1 370, and 1 345 cm^{-1}; δ_H 4.58 (1 H, d, *J* 2 Hz, 14-H), 4.12 (1 H, d, *J* 12 Hz, 20-H), 4.05 (1 H, dd, *J* 10 and 8 Hz, 7-H), 3.96 (1 H, d, *J* 12 Hz, 20-H), 3.56 (1 H, dd, *J* 10 and 4 Hz, 1-H), 2.88 (1 H, m, 16-H), 1.53, 1.45, 1.35, and 1.26 (each 3 H, s, acetonide Me_4), 1.16 (3 H, d, *J* 7 Hz, 16-Me), and 0.95 and 0.91 (each 3 H, s, 4-Me_2) (Found: C, 72.4: H, 9.2. $C_{26}H_{40}O_5$ requires C, 72.19; H, 9.32%).

Kamebakaurinin Tetra-acetate (**14**).—Kamebakaurinin (**13**) (50 mg) dissolved in acetic anhydride–pyridine (1:1; 2 ml) was kept for 5 days at room temperature. Work-up as before gave a residue (59.7 mg), which was recrystallized from methanol to give the tetra-acetate (**14**) (28.1 mg) as colourless needles, m.p. 228—230 °C; $\lambda_{max.}$ 235 nm (ε 8 350); $\nu_{max.}$ 1 740br, 1 650, 1 370, and 1 230br cm^{-1}; δ_H 6.04 (1 H, br s, 17-H), 5.71 (1 H, d, *J* 1 Hz, 14-H), 5.34 (1 H, br s, 17-H), 5.33 (1 H, dd, *J* 11 and 6 Hz, 7-H), 5.19 (1 H, d, *J* 4 Hz, 11-H), 5.05, 4.40 (each 1 H, ABd, *J* 12 Hz, 20-H_2), 3.01 (1 H, m, 13-H), 2.70 (1 H, ddd, *J* 14 and 4 and 4 Hz, 12-axH), 2.12, 2.03, 1.93, and 1.83 (each 3 H, s, Ac_4), and 0.91 (6 H, s, 4-Me_2); *m/z* 458 $(M - CH_3COOH)^+$ (Found: C, 64.9; H, 7.4. $C_{28}H_{38}O_9$ requires C, 64.50; H, 7.55%). This compound is identical with rastronol F triacetate (mixed m.p. and i.r. spectrum).

Dihydrokamebakaurinin (**15**).—Platinum oxide (5 mg) was added to a solution of kamebakaurinin (**13**) (73.5 mg) in methanol (20 ml), and the mixture was stirred for 30 min under an atmosphere of hydrogen. Work-up as before gave a residue (67 mg), which was recrystallized from methanol to give the dihydrokamebakaurinin (**15**) (25 mg) as colourless needles, m.p. 272—275 °C; $\nu_{max.}$ 3 300 and 1 725 cm^{-1}; δ_H (C_5D_5N) 7.77 (1 H, d, *J* 6 Hz, OH), 7.43 (1 H, m, OH), 6.10 (1 H, m, OH), 5.64 (1 H, br s, 14-H), 5.52 (1 H, m, OH), 4.75 (1 H, d, *J* 5 Hz, 11-H), 4.26 (2 H, s, 20-H_2), 3.40 (1 H, m, 16-H), 3.12 (1 H, ddd, *J* 14 and 5 and 5 Hz, 12-ax.H), 1.68 (3 H, d, *J* 7 Hz, 16-Me), and 0.78 (6 H, s, 4-Me_2); o.r.d. $\lambda_{max.}$(MeOH) nm (φ) 317 (−3 090) and 288 (−174) [Found: $(M - H_2O)^+$, 334.2174. $C_{20}H_{30}O_4$ requires *M*, 334.2145].

Anhydro-acetonide (**17**).—2,2-Dimethoxypropane (1 ml) and toluene-*p*-sulfonic acid (1.6 mg) were added to a suspension of kamebakaurinin (**13**) (50 mg) in anhydrous acetone (35 ml) and the mixture was stirred for 20 h at room temperature. Work-up as before gave a residue (55 mg) which was purified by column chromatography (SiO_2 1.5 g; chloroform) to give the acetonide (**17**) (35 mg). Recrystallization from methanol gave colourless needles, m.p. 150—153 °C; $\lambda_{max.}$ 228 nm (ε 7 745); $\nu_{max.}$ 1 730, 1 650, 1 382, and 1 370 cm^{-1}; δ_H 6.08 (1 H, br s, 17-H), 5.41 (1 H, br s, 17-H), 4.82 (1 H, d, *J* 2 Hz, 14-H), 4.34 (1 H, dd, *J* 12 and 6 Hz, 7-H), 4.13 (1 H, t, *J* 6 Hz, 11-H), 3.80 and 3.67 (each 1 H, ABd, *J* 9 Hz, 20-H_2), 2.96 (1 H, br d, *J* 8 Hz, 13-H), 1.76 and 1.23 (each 3 H, s, acetonide Me_2), and 0.93 and 0.68 (each 3 H, s, 4-Me_2) (Found: C, 73.7; H, 8.8. $C_{23}H_{32}O_4$ requires C, 74.16; H, 8.66%).

Dihydrokamebacetal A (**19**).—Platinum oxide (5 mg) was added to a solution of kamebacetal A (**18**) (150 mg) in methanol (15 ml), and the mixture was stirred for 30 min under an atmosphere of hydrogen. Work-up as before gave a residue (155 mg), which was purified successively by column chromatography (SiO_2 10 g; 10% acetone–chloroform) and preparative layer chromatography (SiO_2; 10% acetone–methylene dichloride, developed twice) to give dihydrokamebacetal A (**19**) (57 mg) as colourless needles, m.p. 200—202 °C; $\nu_{max.}$ 3 400 and 1 730 cm^{-1}; δ_H (C_5D_5N) 6.92 (1 H, m, OH), 5.44 (1 H, s, 20-H), 5.20 (1 H, br changed to d on addition of D_2O, *J* 2 Hz, 14-H), 4.59 (1 H, br d, *J* 4 Hz, 7-H), 4.36 (1 H, br d, *J* 8 Hz, OH), 3.32 (3 H, s, OMe), 1.13 (3 H, d, *J* 7 Hz, 16-Me), and 0.96 and 0.79 (each 3 H, s, 4-Me_2); o.r.d. $\lambda_{max.}$(MeOH) nm (φ) 328 (−5 824) and 286 (4 368) [Found: $(M - CH_3OH, H_2O)^+$, 314.1873. $C_{20}H_{26}O_3$ requires *M*, 314.1883).

Kamebacetal A Diacetate (**20**).—Kamebacetal A (**18**) (32 mg) dissolved in acetic anhydride–pyridine (1:1; 2 ml) was kept for 72 h at room temperature. Excess of methanol was added to the mixture and solvent was evaporated under reduced pressure to give a residue (36 mg), which was purified by preparative layer chromatography (SiO_2; methylene dichloride) to afford the diacetate (**20**) (22 mg) as colourless needles, m.p. 162—165 °C; $\lambda_{max.}$ 234.5 nm (ε 8 660); $\nu_{max.}$ 3 400, 1 710, 1 640, and 1 240 cm^{-1}; δ_H 6.04 (1 H, d, *J* 1.5 Hz, 14-H), 5.94 (1 H, br s, 17-H), 5.29 (1 H, br s, 17-H), 5.23 (1 H, d, *J* 1.5 Hz, 20-H), 4.68 (1 H, dd, *J* 9 and 7 Hz, 1-H), 4.05 (1 H, dd, *J* 4 and 2 Hz, 7-H), 3.40 (3 H, s, OMe), 1.99 (6 H, s, Ac_2), and 0.99 and 0.87 (each 3 H, s, 4-Me_2) [Found: $(M - OCH_3)^+$, 415.2136. $C_{24}H_{31}O_6$ requires *M*, 415.2121].

δ-*Lactone* (**23**) *from Kamebakaurin* (**1**).—Jones reagent (diluted 10 times with anhydrous acetone, 0.74 ml) was added to an ice-cooled solution of kamebakaurin (**1**) (100 mg) in anhydrous acetone (10 ml). The mixture was stirred for 5 min at 0 °C. Work-up as before (ethyl acetate was used in the extraction) gave a residue (94 mg): this procedure was repeated twice. The combined residues (197 mg) were purified successively by column chromatography (SiO_2 10 g; methylene dichloride) and preparative layer chromatography (SiO_2; 5% acetone–methylene dichloride, developed three times) to give the δ-lactone (**23**) (17 mg) as colourless needles, m.p. 265—268 °C; $\lambda_{max.}$ 231 nm (ε 9 040); $\nu_{max.}$ 3 300, 1 720, 1 708, and 1 070 cm^{-1}; δ_H ($CDCl_3$ + C_5D_5N) 6.08 (1 H, br s, 17-H), 5.41 (1 H, br s, 17-H), 5.06 (1 H, dd, *J* 4 and 2 Hz, 7-H), 4.53 (1 H, br s, 14-H), 3.31 (1 H, dd, *J* 8 and 8 Hz, 1-H), and 3.02 (1 H, br d, *J* 10 Hz, 13-H), and 0.83 (6 H, s, 4-Me_2) (Found: M^+, 346.1792. $C_{20}H_{26}O_5$ requires *M*, 346.1781).

Demethylkamebacetal A (**22**).—Oxalic acid (50 mg) was added to a solution of kamebacetal A (**18**) (100 mg) in tetrahydrofuran–water (2:1; 12 ml) and the mixture was refluxed for 2 h. The solvent was removed under reduced pressure and the residue was extracted with ethyl acetate (25 ml × 3), after dilution with water (25 ml). The ethyl acetate extract was washed with water, dried, and evaporated under reduced pressure to give a residue (103 mg) which was purified by preparative layer chromatography (SiO_2; 30% acetone–methylene dichloride) to afford demethylkamebacetal A (**22**) (78 mg) as a syrup, $\lambda_{max.}$ 232 nm (ε 5 725); $\nu_{max.}$ 3 300, 1 720, and 1 640 cm^{-1}; δ_H 10.48 (*ca.* 0.2 H, br s, 20-H), 6.13 (*ca.* 0.2 H, br s, 17-H), 5.96 (*ca.* 0.8 H, br s, 17-H), 5.77 (1 H, s, 14-H), 5.40 (*ca.* 0.2 H, br s, 17-H), 5.33 (*ca.* 0.8 H, br s, 17-H), 4.91 (*ca.* 0.8 H, s, 20-H), 4.37 (*ca.* 0.2 H, m, 7-H), 4.19 (*ca.* 0.8 H, br s, 7-H), and 0.95 and 0.84 (each 3 H, s, 4-Me_2) [Found: $(M - H_2O)^+$, 330.1858. $C_{20}H_{26}O_4$ requires *M*, 330.1832]. This compound is an equilibrium mixture of the hemiacetal and the aldehyde in a ratio of *ca.* 4:1 judged from the ^1H n.m.r. spectrum.

Jones Oxidation of Demethylkamebacetal A (**22**).—Jones reagent (1 drop) was added to an ice-cooled solution of demethylkamebacetal A (**22**) (15 mg) in anhydrous acetone (1 ml) and the mixture was stirred for 5 min at 0 °C. Work-up as before gave a residue (15 mg), which was purified by preparative layer chromatography (SiO_2; 20% acetone–methylene dichloride) to give the δ-lactone (**23**) (2 mg) as colourless needles. This compound was identical with the δ-lactone (**23**) derived from kamebakaurin (**1**) (i.r. spectra and mixed m.p.).

Dihydrokamebacetal B (**25** + **26**).—Platinum oxide (3 mg) was added to a solution of kamebacetal B (**24**) (50 mg) in methanol (10 ml) and the mixture was stirred for 30 min under an atmosphere of hydrogen. Work-up as before gave a residue

(53 mg), which was purified by preparative layer chromatography (SiO_2; 4% methanol–chloroform, developed three times) to give dihydrokamebacetal B(**25** + **26**) as a syrup; $\nu_{max.}$ 3 400, 1 730, and 1 060 cm^{-1}; $\delta_H(C_5D_5N)$ 7.00 (1 H, m, OH), 5.54 (1 H, m, OH), 5.48 (1 H, s, 20-H), 5.01 (*ca.* 0.7 H, br s, 14-H), 4.84 (*ca.* 0.3 H, br s, 14-H), 4.69 (1 H, t, *J* 3 Hz, 7-H), 3.69 (1 H, m, changed to dd on addition of D_2O, *J* 11 and 5 Hz, 1-H), 3.45 (3 H, s, OMe), 3.17 (1 H, m, 16-H), 1.53 (*ca.* 0.9 H, d, *J* 7 Hz, 16α-Me), 1.25 (*ca.* 2.1 H, d, *J* 7 Hz, 16β-Me), and 1.22 and 0.97 (each 3 H, s, 4-Me_2); o.r.d. $\lambda_{max.}$(MeOH) nm (φ) 323 (−2 371) and 282 (688) [Found: $(M - CH_3OH)^+$, 332.1974. $C_{20}H_{28}O_4$ requires *M*, 332.1988]. This compound is the mixture of 16β-Me (**25**) and 16α-Me (**26**) derivatives in a ratio of *ca.* 7:3 as judged from the ^1H n.m.r. spectrum.

Kamebacetal B Diacetate (**27**).—Kamebacetal B (**24**) (102 mg) dissolved in acetic anhydride–pyridine (1:1; 4 ml) was kept for 24 h at room temperature. Work-up as before gave a residue (114 mg) which was purified by column chromatography (SiO_2 4 g; methylene dichloride) to give the diacetate (**27**) (103 mg) as an amorphous powder; $\nu_{max.}(CHCl_3)$ 1 740, 1 660, 1 240, and 1 030 cm^{-1}; δ_H 6.05 (1 H, br s, 17-H), 5.40 (2 H, br s, 17-H, 14-H), 4.97 (1 H, s, 20-H), 4.57 (1 H, dd, *J* 11 and 6 Hz, 1-H), 4.07 (1 H, *t*, J 3 Hz, 7-H), 3.40 (3 H, s, OMe), 3.09 (1 H, br d, *J* 9 Hz, 13-H), 2.67 (1 H, ddd, *J* 13, 10 and 3 Hz, 6-axH), 2.00 and 1.98 (each 3 H, s, Ac_2), and 1.04 and 0.92 (each 3 H, s, 4-Me_2) [Found: $(M - OCH_3)^+$, 415.2140. $C_{24}H_{31}O_6$ requires *M*, 415.2121].

Demethylkamebacetal B (**22**).—Oxalic acid (30 mg) was added to a solution of kamebacetal B (**24**) (60 mg) in tetrahydrofuran–water (2:1; 9 ml) and the mixture was refluxed for 6.5 h. Work-up as before gave a residue (57 mg) which was purified by preparative layer chromatography (SiO_2; 30% acetone–methylene dichloride) to give demethylkamebacetal B (**22**) (19.2 mg). This compound was identified by comparison with demethylkamebacetal A (**22**) (i.r. and ^1H n.m.r. spectra).

Jones Oxidation of Demethylkamebacetal B (**22**).—Jones reagent (2 drops) was added to an ice-cooled solution of demethylkamebacetal B (**22**) (8 mg) in anhydrous acetone (5 ml) and the mixture was stirred for 5 min at 0 °C. Work-up as before gave a residue which was recrystallized from methanol to give the δ-lactone (**23**) (2 mg) as colourless needles. This compound was identified by comparison with the δ-lactone (**23**) derived from kamebacetal A (**18**) (mixed m.p. and i.r. spectrum).

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