# STRUCTURE AND SYNTHESIS OF BATATASINS, DORMANCY-INDUCING SUBSTANCES OF YAM BULBILS

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Abstract-- Batatasin, which occurs in dormant bulbils of yams (*Dioscorea batatas* Decne) and induces dormancy in this organ has been shown by spectrometric analysis and synthesis to be 3.3'-dihydroxy-5-methoxy-bibenzyl

#### INTRODUCTION

YAM PLANTS (*Dioscorea batatas* Decne.) form bulbils (small tubers) at the axils for propagation in late summer and autumn when vigorous growth of the shoots ceases. At maturity the bulbils are dormant and contain three growth inhibitors, batatasins I, II and III, which induce the dormancy. Of these inhibitors only batatasins I and III have been isolated as crystalline substances <sup>1</sup> The present paper describes these natural products, elucidates the structure of batatasin III, and also reports a new synthetic route for batatasin I.

#### **RESULTS AND DISCUSSION**

### Batatasin I (B-I)

The molecular formula,  $C_{17}H_{16}O_4$ , and UV absorption (with alkali shift) suggested the presence of a substituted anthranol<sup>2</sup> or phenanthrol.<sup>2,3</sup> The NMR spectrum indicated that B-I was a hydroxy-trimethoxyphenanthrene. Methylation of B-I with dimethylsulfate gave a product which was identical (m p., IR) with synthetic 2,4,6,7-tetramethoxyphenanthrene<sup>4</sup> (2). Using the above information, Letcher<sup>5</sup> synthesized 6-hydroxy-2,4,7-trimethoxyphenanthrene (1), with which B-I was identified by comparison of mixed m.p., IR, MS and NMR spectra

A Wittig condensation of 3,5-dimethoxybenzyltriphenylphosphonium bromide (4) and

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<sup>&</sup>lt;sup>5</sup> LITCHER, R M (1973) Phytochemistry 12, 2789

4-benzyloxy-3-methoxybenzaldehyde (5) gave cis and trans 4-benzyloxy-3.3'.5-trimethoxystilbene (6), which was cyclized by UV irradiation and hydrogenolyzed to (1)

# Batatasın III (B-III)

The UV absorption (and alkali shift) suggested that B-III,  $C_{15}H_{16}O_3$  was a bibenzyl possessing hydroxyl groups.<sup>2,6</sup> It gave positive tests with vanillin-H<sub>2</sub>SO<sub>4</sub> and Gibbs' reagent.<sup>8</sup> showed  $v_{OH}$  3600- 3180 cm<sup>-1</sup>, and a two-proton broad singlet at  $\delta$  4·80, exchangeable with D<sub>2</sub>O. The NMR spectrum also included a methoxyl signal at  $\delta$  3·76 and a singlet (4H) at  $\delta$  2.83 assigned to an ArCH<sub>2</sub>CH<sub>2</sub>Ar Ph moiety. The presence of two hydroxyl groups was confirmed by silvlation and acetylation followed by GC-MS



R = phenyl

<sup>6</sup> LEICHER, R. M. NHAMO, L. R. M. and GUMIRO, I. T. (1972) J. C. S. Perkin I, 206

<sup>7</sup> Dyeing Reagents for Thin Layer and Paper Chromatography, p 49, E Merck AG Darmstadt

<sup>8</sup> KING F E, KING T J and MANNING L C (1957) J Chem Soc, 563

Intense peaks in the MS at m/e 107 (rel. intensity 36%) and 137 (rel. intensity 100%), which were identified as a hydroxytropylium and a hydroxymethoxytropylium ion, respectively, indicated that the two hydroxyl groups were situated one in each benzene ring To locate the position of the hydroxyl and methoxyl groups on the benzene rings the chemical shifts and the splitting patterns of the signals in the aromatic region of NMR of B-III and related phenolic compounds were compared. The two-proton doublet at  $\delta$  6.25 and the 1-proton doublet at  $\delta$  6.34 of B-III corresponded to the signals of the three protons of 3-hydroxy-5-methoxytoluene, and the 3-proton multiplet centered at  $\delta$  6.70 and the 1-proton triplet at  $\delta$  7.15 (J 8 Hz) to the three protons (o and p to OH) and the one proton (m) in m-cresol These moieties thus represent the two ring systems of B-III.

A Wittig condensation of 3-benzyloxy-5-methoxybenzyltriphenyphosphonium bromide (7) and 3-benzyloxybenzaldehyde gave *cis* and *trans* 3,3'-dibenzyloxy-5-methoxystilbene (8), which was then hydrogenated in the presence of palladium on carbon. The product 3,3'-dihydroxy-5-methoxybibenzyl (9) was identical (mixed m.p., GLC, MS and IR) with B-III Accordingly, B-III was concluded to have structure (9).

Although several hydroxy- and methoxyl-substituted phenanthrenes and bibenzyls have previously been obtained from plant sources<sup>5,6,9</sup> <sup>13</sup> the occurrence of 6-hydroxy-2,4,7-trimethoxyphenanthrene and 3,3'-dihydroxy-5-methoxybibenzyl has not been previously recorded. The compounds are also new phenolic plant growth regulators.

#### EXPERIMENTAL

100 MHz NMR spectra were determined in  $CDCl_3$  with TMS as internal standard. M ps were measured with a Kofler block and are uncorrected

Batatasın I From dormant yam bulbils (273 kg) were isolated crystals (25 mg) which on recrystallization from  $C_6H_6$ -n-hexane gave yellowish rods, and from MeOH-H<sub>2</sub>O, colorless needles, both types of crystals had the same m p 148 5 149 5 . UV  $\lambda_{max}^*$  362 (log  $\epsilon$  3 91), 355 (sh) (3 64), 344 (3 83), 328 (3 64), 307 (sh) (4 00) 296 (sh) (4 11), 283 (sh) (4 24), 261 (4 94), 252 (sh) (4 78), 237 (sh) (4 48) and 221 (sh) nm (4 45) m 001 N HCI-containing or plain EtOH, 371 (4 11), 353 (3 97), 334 (3 95), 296 (sh) (4 12), 269 (sh) (4 71), 258 (4 77) and 225 (sh) nm (4 43) in EtOH containing 0005 N KOH, IR (KBr)  $v_{max}$  3600-3310, 1625, 1615, 1580, 1503, 1485, 1462, 1436, 1303, 1286, 1266, 1208, 1191, 1162, 1154, 1139, 1089, 1062, 881, 853, 827, 818 cm<sup>-1</sup>, MS *m/e* 284 1044 (M<sup>+</sup>, relative intensity 100° <sub>0</sub> C<sub>1.7</sub>H<sub>16</sub>O<sub>4</sub> requires M, 284 1049), 269 (28°<sub>0</sub>), 241 (15°<sub>0</sub>), NMR  $\delta$  3 94 (3H, s, MeO), 4 02 (3H, s, MeO), 5 83 (1H, broad, D<sub>2</sub>O-exchangeable s, OH), 6 72 (1H, *d*, *J* 2 5 Hz, H-1 or H-3), 6 87 (1H, *d*, *J* 2 5 Hz, H-3 or H-1), 7 18 (1H, s, H-8), 7 47 (1H, *d*, *J* 8 8, H-9 or H-10), 7 60 (1H, *d J* 8 8, H-10 or H-9), and 9 07 (1H s, H-5)

Synthesis of B-1 3 5-Dimethoxybenzyl bromide<sup>14</sup> was mixed with triphenylphosphine in dimethylformamide at 100° for 1 hr to prepare 3.5-dimethoxytriphenylphosphonium bromide (4) in 85° o yield. The phosphonium salt (4) and 4-benzyloxy-3-methoxybenzaldehyde (5) were refluxed with NaOEt in EtOH for 2 hr to obtain in 70° o yield trans-4-benzyloxy-3.3°.5-trimethoxystibene (4), m p 157.0-157.5 (from EtOH) IR v<sup>KBr</sup><sub>max</sub> 1595, 970 cm<sup>-1</sup> and the corresponding cis isomer, an oil, IR v<sup>KBr</sup><sub>max</sub> 1595 cm<sup>-1</sup> (ratio of trans and cis isomers was about 2.1). The mixed isomers were irradiated with a Hg arc in the presence of I<sub>2</sub> (0.02° o) in EtOH), NMR  $\delta$  383 (6H, s), 397 (3H, s), 532 (2H s) 658 677 (2H, AB typed q), 71-76 (4H, m), 90 (1H s), MS m.e. 374 (M<sup>-2</sup> C<sub>24</sub>H<sub>22</sub>O<sub>4</sub>), 283 Catalytic hydrogenolysis of 3 with Pd on C in HOAc gave 6-hydroxy-2.5.7-trimethoxyphenanthrene (1), m p 145 147 (from CH<sub>2</sub>Cl<sub>2</sub>-*r*-hexane), IR v<sup>KBr</sup><sub>max</sub> 3450, 1620 cm<sup>-1</sup>, NMR  $\delta$  398 (3H, s), 407 (3H s), 412 (3H, s), 683, 697 (2H, AB typed q), 73-77 (4H, m), 899 (1H, s), MS *m*/e 284 (M<sup>+</sup>, C<sub>12</sub>H<sub>16</sub>O<sub>4</sub>), 269

Batatasin III From dormant yam bulbils (273 kg) were isolated crystals (135 mg) which gave colorless rods on recrystallization from CHCl<sub>3</sub> CCl<sub>4</sub> mp 935 945. UV  $\lambda_{max}$ 282 (log  $\epsilon$  379), 275 (381), 226 (sh) (432) and 208 nm (477) in 0.01 N HCl-containing or plain EtOH, 292 (390) 284 (sh) (387) 242 (429) and 215 nm

\* Some corrections of log  $\epsilon$ -values from those described in ref. 1 were made

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(4 74) in EtOH containing 0 005 N KOH, IR  $v_{mix}^{\text{KB}}$  3600- 3180, 1621–1610–1598, 1460, 1440–1345–1300, 1252, 1195, 1154, 1150, 1057, 980, 947, 867, 838–814–782 and 690 cm<sup>-1</sup>, MS *m*/*e* 245 (relative intensity 12°<sub>o</sub>)–244 (M<sup>+</sup>, 62°<sub>a</sub>), 137 (100°<sub>o</sub>), 107 (36%) and 77 (12°<sub>o</sub>) (M<sup>+</sup> - 244 1088 C<sub>15</sub>H<sub>10</sub>O<sub>3</sub> requires M<sup>+</sup> - 244 1099)

*B-HI* acetate A brown oil, UV  $z_{max}^{110H}$  278 (sh) (log  $\epsilon$  3.25) 271 (3.30) 207 nm (4.55), IR  $z_{max}^{11m}$  1767, 1610, 1590 1468, 1435, 1369, 1204 1130, 1060 1018 692 cm<sup>-1</sup> MS *m-e* 328 (M<sup>+</sup>  $C_{19}H_{20}O_5$ ), 286 244 (base peak), 141, 137, 107

Synthesis of B-III 3-Benzyloxy-5-methoxybenzyltiphenylphosphonium bromide (7) was prepared from 3benzyloxy-5-methoxybenzyl bromide and triphenylphosphine in  $85^{\circ}_{o}$  yield by stiring in dimethylformamide at 100 for 1 hr. The phosphonium salt (7) and 3-benzyloxybenzyladehyde were refluxed with NaOEt in EtOH for 2 hr to obtain in  $60^{\circ}_{o}$  yield *trans* 3.3'-dibenzyloxy-5-methoxysulbene (8) ( $32^{\circ}_{o}$ ) an oil IR  $\frac{1}{100}$  1600 960 cm<sup>-1</sup> and the corresponding *cis* isomer ( $28^{\circ}_{o}$ ) an oil IR  $\frac{1}{100}$  1600 cm<sup>-1</sup> Catalytic hydrogenation of the mixed isomers in the presence of Pd on C in EtOH gave in  $80^{\circ}_{o}$  yield 3.3-dihydroxy-5-methoxybibenzyl (9) mp 92 (from CHCl<sub>3</sub> CCl<sub>4</sub>), IR  $\frac{1}{80}$  3400 1620 cm<sup>-1</sup> NMR  $\delta$  2.80 (4H s), 3.78 (3H, s) 6.3.7.2 (7H m) MS m c 244 (M<sup>+</sup> C<sub>1.5</sub>H<sub>1.6</sub>O<sub>3</sub>), 137, 107. The mixture of 3.3-dihydroxy-5-methoxybibenzyl and B-III showed no depression of m p

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