## Communications to the Editor

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# REVISED STRUCTURES OF SOYASAPOGENOLS A, B, AND E, OLEANENE-SAPOGENOLS FROM SOYBEAN. STRUCTURES OF SOYASAPONINS I, II, AND III

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The structures of soyasapogenols A, B, and E, three of five hitherto isolated sapogenols of soybean (*Glycine max* Merrill), were re-investigated. Based on the chemical and X-ray analyses, it has been shown that the structures of soyasapogenols A, B, and E should be partly revised respectively from **1'**, **2'**, and **3'** to **1**, **2**, and **3** and consequently the structures of soyasaponins I, II, and III are expressed as **6**, **7**, and **8**.

KEYWORDS —— soybean; *Glycine max*; oleanene-sapogenol; triterpene-oligoglycoside; soyasapogenols; soyasaponins; photolysis; X-ray analysis

Five oleanene-sapogenols: soyasapogenols A (second major), B (major), C, D, and E, were hitherto isolated from soybean (*Glycine max* Merrill, seeds), and after several structural investigations,[1,2] the structures of soyasapogenols A, B, and E were respectively proposed as **1'**,[3] **2'**,[3] and **3'**.[4] Afterwards, we isolated five oligoglycosides named soyasaponins I, II, and III (aglycone: soyasapogenol B)[5] and soyasaponins $A_1$ and $A_2$ (aglycone: soyasapogenol A),[6] and proposed their structures, in which the triterpene parts were referred to the previous works.[3,4]

Very recently, Chang, *et al.* isolated a new triterpenoid sapogenol cantoniensistriol together with soyasapogenols A and B and sophoradiol from the root of *Arbus cantoniensis* Hance (Leguminosae) and they determined the structures of sophoradiol (**4**) and cantoniensistriol (**5**) by X-ray analysis.[7] Furthermore, based on the co-occurrence of soyasapogenols A and B with **4** and **5**, Chang suggested that the configuration of both C-21 and C-22 hydroxyl groups of soyasapogenol A should most likely be revised from α (**1'**)[3] to β as seen in **5**.[7]

During the course of our studies on chemical modification of triterpene-oligoglycosides, we have also noticed some ambiguity for the reported structural determination regarding the hydroxyl groups in the E ring of soyasapogenols A (**1'**)[3] and B (**2'**)[3] and re-investigated this matter. Based on the chemical and X-ray analyses as shown in this communication, we have found that soyasapogenols A, B, and E should be respectively revised from **1'**, **2'**, and **3'** to **1**, **2**, and **3** and consequently the structures of soyasaponins I, II, and III are formulated as **6**, **7**, and **8**, in which the hydroxyl group in the E ring of the aglycone is revised from 21α[5] to 22β.

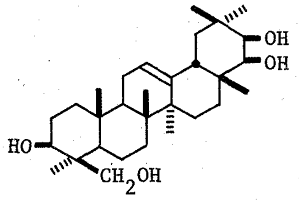
Irradiation of a $CHCl_3$-MeOH solution (in a Pyrex tube) of soyasapogenol E diacetate (**3a**), which was prepared from soyasapogenol B (**2**), with a 500W high pressure Hg lamp at 0-4°C for 2.5h furnished a seco-acid methyl ester (**9**), $C_{35}H_{56}O_6$,8) mp 162-163°C, IR ($CCl_4$): 1737, 1233 $cm^{-1}$, in 85% yield. The $^1H$ NMR spectrum ($CDCl_3$, δ) of **9** indicated occurrence of the C-17,22 bond cleavage of **3a** (α-fission of the 22-CO moiety) rather than the C-20,21 bond cleavage (α-fission of the 21-CO moiety if in **3'**) by signals assignable to six tert. $CH_3$ (0.94, 0.98, 0.99, 1.01, 1.02, 1.05; 3H each, all s), one sec. 17-$CH_3$ (0.86, 3H, d, J= 7.1 Hz), and 21-$CH_2$ (2.16, 2.28; ABq, J= 11.7 Hz).9) The structure of **9** was also supported by its MS spectrum10) [m/z 572 ($M^+$, $C_{35}H_{56}O_6$, 85%), 264 (**i**, $C_{17}H_{28}O_2$, 86%), 248 (**ii**-AcOH, $C_{16}H_{24}O_2$, 22%), 188 (**ii**-AcOH x 2, $C_{14}H_{20}$, 16%)] and $^{13}C$ NMR spectrum.11) In addition, physicochemical properties (IR, UV, $^1H$ NMR) of a dienic compound (**10a**), $C_{35}H_{54}O_6$, mp 115-116°C, which was prepared by $SeO_2$ oxidation of **9**, and of its deacetylated product (**10**), $C_{31}H_{50}O_4$, white powder, showed formation of the C-11,13 (18)-heteroannular diene moiety in **10a**: *e.g.* for **10a**, UV $\lambda_{max}^{MeOH}$ nm (ε): 245 (33000), 253 (37000), 261 (24000)12): δ5.44 (1H, d, J= 10.8 Hz, 11-H), 6.33 (1H, dd, J= 10.8 & 3.0 Hz, 12-H).9) Thus, the location of the oxygen function in the E ring of soyasapogenols B and E was suggested to be at C-22 rather than at C-21 (as seen in **2'** and **3'**). Since the $^1H$ NMR spectrum of **2a** and **20**9) showed the equatorial character of 22-H (t of J= 3.5 Hz, at δ4.64 for **2a** and δ4.61 for **20**), the 22β-OH function of soyasapogenol B (**2**) was proved.

Next, unambiguous conversion from soyasapogenol B (**2**) to sophoradiol (**4**) was carried out. A monotrityl ether (**11**), $C_{49}H_{64}O_3$, mp 293-294°C, was converted to a diphenylurethane (**12**), $C_{63}H_{74}N_2O_5$, mp 157-159°C, which, on heating with dil. HCl under reflux for 20 min, was detritylated to give **13**, $C_{44}H_{60}N_2O_5$, mp 288-290°C. Pyridinium chlorochromate oxidation of **13** gave an aldehyde (**14**), $C_{44}H_{58}N_2O_5$, white powder, which, on Huang-Minlon reduction, was converted to sophoradiol (**4**).7) The overall yield of the conversion from **2** to **4** was 32%.

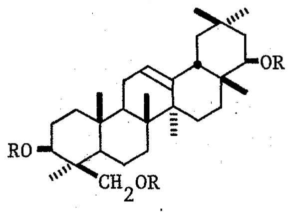
In order to make sure of the revised structure of soyasapogenol B (**2**), the X-ray analysis of the triacetate (**2a**) was carried out. Crystal data. $C_{36}H_{56}O_6$, a= 12.105(2), b= 37.936(5), c= 7.358(1) Å, β= 90.05(1)°, space group $P2_1$, Z= 4 (two molecules in an asymmetric unit), $D_x$= 1.15, $D_m$= 1.11 $g.cm^{-3}$, μ= 6.13 $cm^{-1}$(Cu Kα). Intensities were measured on a Rigaku C5 diffractometer with a rotating anode X-ray generator (40 Kv, 200 mA) employing ω-2θ scan mode. The structure was solved by the direct method and refined with anisotropic temperature factors except isotropic ones for 53 hydrogen atoms to a conventional R value of 0.094, using 3052 reflections. Since the molecular geometries of the two independent molecules are essentially same, a perspective view of one molecule is shown in Fig. 1.

As the structure of soyasapogenol B has now been fully defined as 3β,22β,24-trihydroxyolean-12-ene (**2**), soyasapogenol E is shown to be the 22-keto derivative (**3**). Furthermore, based on the previously reported evidence on the structures of soyasaponins I, II, and III,5) the structures of these oligoglycosides have also been revised as **6**, **7**, and **8**, respectively.

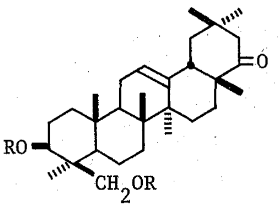
Next, revision of the structure of soyasapogenol A has been shown by the following chemical correlation with soyasapogenol B (**2**). A monoacetonide of soyasapogenol A (**15**), $C_{33}H_{54}O_4$, mp 268-269°C, was methylated with $CH_3I$ and NaH in tetrahydrofuran13) to afford quantitatively the dimethyl ether (**16**), $C_{35}H_{58}O_4$, mp 239-240°C. Removal of the isopropylidene group from **16** with acid followed by



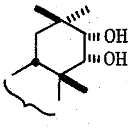
1 (soyasapogenol A)



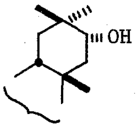
2 : R= H (soyasapogenol B)
2a : R= Ac



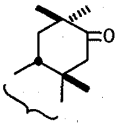
3 : R= H (soyasapogenol E)
3a : R= Ac



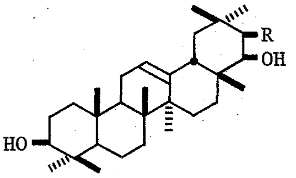
1'



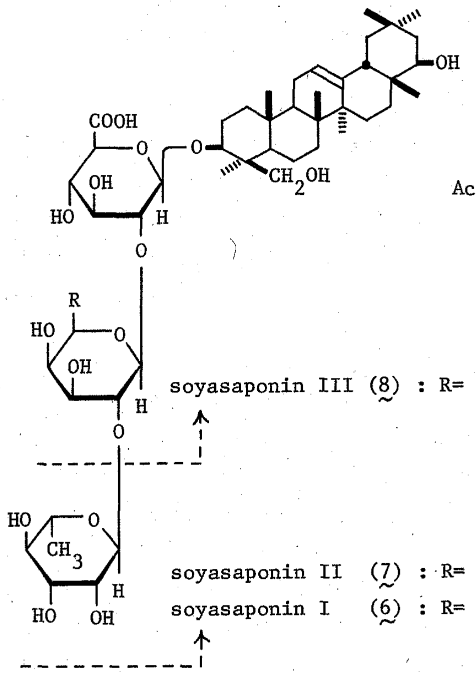
2'



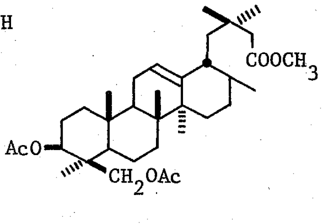
3'



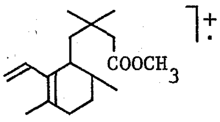
4 : R= H (sophoradiol)
5 : R= OH



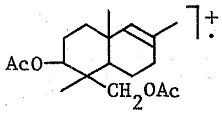
soyasaponin III (8) : R= $CH_2OH$
soyasaponin II (7) : R= H
soyasaponin I (6) : R= $CH_2OH$



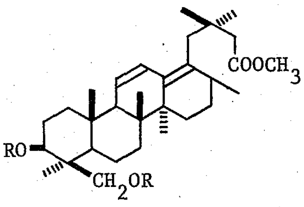
9



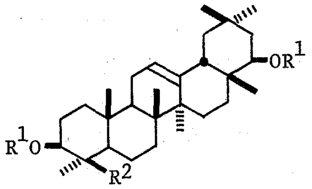
i



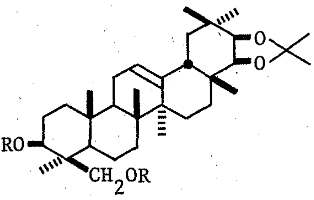
ii



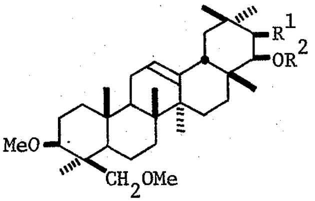
10 : R= H
10a : R= Ac



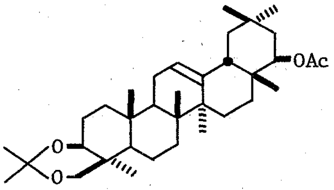
11 : $R^1$= H, $R^2$= $CH_2OTr$
12 : $R^1$= $CONHC_6H_5$, $R^2$= $CH_2OTr$
13 : $R^1$= $CONHC_6H_5$, $R^2$= $CH_2OH$
14 : $R^1$= $CONHC_6H_5$, $R^2$= CHO



15 : R= H
16 : R= Me



17 : $R^1$= OAc, $R^2$= H
18 : $R^1$= $R^2$= H
20 : $R^1$= H, $R^2$= Ac



19

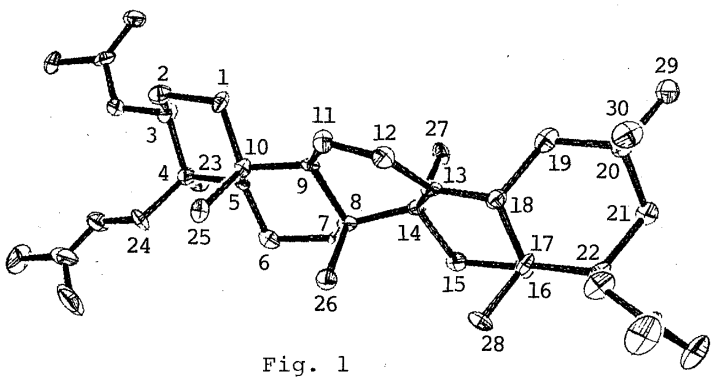


Fig. 1

partial acetylation gave a monoacetate dimethyl ether (**17**), $C_{34}H_{56}O_5$, mp 229-230°C, IR($CCl_4$): 3610, 1740, 1240 $cm^{-1}$, which retained an axial 22-OH group. The $^1H$ NMR spectrum of **17** supported the structure[9]: *e.g.* δ 3.44 (1H, d, J= 2.4 Hz, 22-H) and δ4.94 (1H, d, J= 2.4 Hz, 21-H). Photochemical removal of the acetoxyl function[14] of **17** in a hexamethylphosphoric triamide-water (95:5) solution (in a quartz tube) by irradiation with a 30W low pressure Hg lamp at 10°C for 48 h furnished **18**, $C_{32}H_{54}O_3$, mp 228-229°C, in 81% yield. The product was identical with 3,24-di-O-methylsoyasapogenol B (**18**), which was synthesized from **2** *via* a monoacetonide monoacetate (**19**), $C_{35}H_{56}O_4$, mp 239-240°C, and a monoacetate dimethyl ether (**20**), $C_{34}H_{56}O_4$, mp 209-210°C. The overall yield of the conversion from **2** to **18** was 73%. Consequently, the structure of soyasapogenol A has been now defined as 3β,21β,22β,24-tetrahydroxyolean-12-ene (**1**) rather than previously proposed **1'**.[3]

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8) The compounds given with the chemical formulae gave the satisfactory analytical values.
9) Measured by a JEOL FX-200 (200 MHz) NMR spectrometer. The assignments were made on the basis of decoupling experiments and Eu(fod)$_3$- and solvent-induced shift experiments.
10) The elemental compositions were determined by high resolution MS.
11) The C-17 configurations in **9**, **10**, and **10a** have not yet been defined.
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