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MOLLUSCICIDAL STEROIDAL SAPONINS FROM *YUCCA ELEPHANTIPES*

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ABSTRACT

Three spirostanol and two furostanol saponins have been isolated from the methanol extract of the leaves of *Yucca elephantipes* .The structures of these saponins were established as 3-O-β-D-xylopyranosyl-(1→2)[- β-D-glucopyranosyl-(1→3)]- β-D-glucopyranoside yamogenin **(I)**,3-O-β-D-xylopyranosyl-(1→2) [-β- D-glucopyranosyl-(1→3)], 26-β-D- glucopyranoside (25 S) -furost- 5-ene-3,22,26 –triol **(II)**, 3- O- α -L - rhamnopyranosyl- (1→2)- [β- D-xylopyranosyl- (1→3)] -β-D-glucopyranosyl-(1→4)- β-D-galactopyranoside gitogenin **(III)**, 3-O-β-D-xylopyranosyl- (1→ 3)-[β-D–glucopyranosyl -(1→2)]- β-D-glucopyranosyl-(1→4)- β-D-galactopyranoside gitogenin **(IV)**,and 26-O-β-D-glucopyranosyl-22-O-methyl (25R)-5-furostan -2,3,26-tetrol-3-O- [α-L-rhamnopyranosyl -(1→3)] – β – D –glucopyranosyl -(1→2)- β-D-glucopyranosyl-(1→4)- β-D-galactopyranoside **(V)**. Saponins **I**, **III** and **IV** showed high molluscicidal activities against *Biomphalaria alexandrina* snails after 24 hours exposure (LC_{90} = 4,9 and 7 ppm) whereas saponins **II** and **V** were inactive up to 50 ppm

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INTRODUCTION

The parasitic disease schistosomiasis is widespread in many tropical and subtropical countries .The rising costs of chemotherapy and synthetic molluscicides have led to an increasing interest in plants and plant-derived compounds, which are lethal to the intermediate host of schistosomiasis [1,2]. The use of plants with molluscicidal properties appears to be a simple and inexpensive technology for the control of the snail vector. There is still an urgent need for highly potent plant molluscicides in order to avoid the transmission of this parasitic disease [2,3].

Yucca species is a very common ornamental plant in Egypt and other countries. Considerable phytochemical work on the *Yucca* genus has been done and the isolation of several steroidal sapogenins and saponins has been reported [4-8]. However, no detailed chemical investigation appears to have been performed on *Yucca elephantipes*. In the same time, it has been found that the aqueous suspension of the leaves of *Yucca elephantipes* had strong molluscicidal activity against *Biomphalaria alexandrina*, the intermediate host of *Schistosoma mansoni* in Egypt. Therefore, our attention was drawn to isolate and identify the molluscicidal ingredients of this plant.

EXPERIMENTAL

GENERAL:

Melting points were uncorrected. IR spectra were measured on a Perkin-Elmer model FT-IR recording spectrophotometer. ^{1}H-NMR and ^{13}C-NMR spectra were recorded at 360 and 100 MHz respectively in DMSO-d_6 as solvent and TMS as internal standard. Mass spectra were measured on a Finnigan TSQ 700 GC\MC equipped with a Finnigan electrospray source (EI-MS and CI-MS).Column chromatography was carried out on silica gel 60 (Sigma 28-200 mesh) and Sephadex LH-20 columns. TLC was performed on silica gel plates (Merck, Kiselgel 60, GF254, 0.5 mm). Spots were visualized by spraying with 40 % H_2SO_4 followed by heating at 120°C. Centrifugal chromatography device was used for performing preparative chromatographic separations. Paper chromatography was performed on Whatman paper NO.1 using descending technique and visualized with aniline –phthalate.

PLANT MATERIAL

The fresh leaves of *Yucca elephantipes* (Family Agavaceae) were collected from the Botanical Orman Garden, Giza, Egypt .The plant was kindly authenticated by Prof. Dr. N. El-Hadidi Professor of Plant Taxonomy, Faculty of science, Cairo University and by specialists in the garden .The leaves were shade dried and powdered by electrical mill.

EXTRACTION AND ISOLATION

The air-dried powdered leaves of the plant (2.5 Kg) were extracted with methanol. The methanolic extract was concentrated under reduced pressure using rotatory evaporator then was defatted with petroleum ether (60 - 80°C). The defatted material was diluted with water and successively extracted with chloroform, ethyl acetate and n-butanol. The butanolic layer was chromatographed over silica gel column using solvents of increasing polarity starting with chloroform followed by mixtures of chloroform in methanol and ending with methanol. Fractions of 250 ml were collected according to their TLC behavior. Three major fractions I-III were obtained. Fraction I eluted with $CHCl_3$: MeOH , 85 : 15 was chromatographed on preparative TLC using solvent system ($CHCl_3$:MeOH : H_2O ; 13 : 7:1) to give compound **1**. Two other fractions II and III were chromatographed on Centrifugal chromatography device using a gradient solvents starting with $CHCl_3$, mixtures of $CHCl_3$ and MeOH and ended with methanol. The isolated compounds were purified on Sephadex LH-20 columns to give saponins **2-5**.

Saponin **I**, white powder, m.p. 218-220 °C , R_f 0.34 ($CHCl_3$: MeOH : H_2O ; 13: 7 : 1) . IR (KBr) ν max cm^{-1} 3408, 2934, 1638, 1378, 1255,1163,1075,972,961,925,892 ,839 and 620 (925 > 892;25S-spiroketal) . ^{1}H-NMR δ 0.71 (3H, s, Me-18), δ 0.82 (3H,d,Me-27), δ1.01(3H,s,Me-19), δ1.11(3H, d, Me-21), δ4.84 (1H, d, H-1 of Glc), δ4.86 (1H, d,H-1 of Glc), δ5.11(1H, d, H-1 of Xyl) and δ 5.32 (1H, s, H-6). CI-MS; m\z 869 [M$^+$], 737.2[M$^+$-Xyl], 575[M$^+$-Xy-Glc] and 413 [M$^+$-Xyl-2Glc].^{13}C–NMR see tables 1 and 2 .

Saponin **II**, white powder , m.p. 198-200°C , R_f 0.29 ($CHCl_3$: MeOH : H_2O ; 13 : 7 : 1). IR (KBr) ν max cm $^{-1}$ 3401,2930,1637,1461, 1367, 1259, 1162, 1075, 890, 799 and 674. ^{1}H-NMR δ0.72 (3H,s,Me-18), δ 0.80 (3H,d, Me-27), δ 0.98 (3H,s,Me-19), δ 4.82 (1H,d, H-1 of Glc), δ4.86 (1H,d,H-1 of Glc), δ4.98 (1H,d,H-1 of Glc), δ5.17(1H,d,H-1 of Xyl) and δ5.30 (1H,s,H-6). CI-MS ; m\z 1023.9 [M$^+$], 871.4 [M$^+$-Xyl-H_2O], 709.1[M$^+$-Xyl-Glc-H_2O], 579.6 [M$^+$ - Xyl - 2Glc - H_2O] and 415.6[M$^+$-Xyl-2Glc-H_2O].^{13}C-NMR see tables 1 and 2 .

Saponin **III** , white powder,m.p.258-259 °C, R_f 0.24 ($CHCl_3$: MeOH :H_2O ; 14:6:1). IR (KBr) νmax cm^{-1} 3397,2931, 1377,1252, 1164,1060,921,898 and 864 (Intensity 898 > 921 , 25R-spiroketal).^{1}H-NMR δ 0.70 (3H,s,18 -Me), δ0.81 (3H,d,27-Me), δ 0.98 (3H,s,19-Me), δ1.11 (3H,s,21-Me) , δ1.62 (3H,d,Me of Rha), δ 4.74 (1H,d,H-1 of Gal), δ4.86(1H,d,H-1 of Glc), δ4.96(1H,d,H-1 of Rha) and δ5.09(1H,H-1of Xyl}.CI-MS ;m\z 1031.7[M$^+$],887.8[M$^+$-Rha] , 755.5 [M$^+$ - Rha-Xyl], 593.4 [M$^+$- Rha - Xyl - Glc] , 431[M$^+$ - Rha-Xyl-Glc-Gal] .^{13}C-NMR see tables 1 and 2.

Saponin **IV**, amorphous powder, m.p. 249-251°C,.IR (KBr) νmax cm^{-1} 33934,1643,1450, 1375, 1240, 1070, 949, 919, 900 and 866 (Intensity 900 > 919,25R-spiroketal). ^{1}H-NMR δ0.69 (3H,s,18-Me), δ 0.74 (3H,d, 27-Me), δ0.80 (3H,d,19-Me), δ1.19 (3H,s,21-Me), δ4.76 (1H,H-1of Gal), δ4.80 (1H,H-1 of Glc) , δ4.92 (1H,H-1 of Glc) and δ 5.12 (1H,S,H-1 of Xyl). CI-MS ; m\z 1049[M$^+$],917[M$^+$-Xyl], 755.4[M$^+$-Xyl-Glc] ,593.6[M$^+$-Xyl-2Glc] and 431.3[M $^+$-2Glc-Gal].^{13}C-NMR see tables 1 and 2 .

Saponin **V**, amorphous powder, m.p. 240-242°C, R_f 0.21 ($CHCl_3$: MeOH : H_2O,14 : 6 : 1). IR (KBr) νmax cm^{-1} 3409,2932,1448,1383,1240, 1165, 1072, 980, 920, 799. ^{1}H-NMR δ0.71(3H,d,27-Me), δ0.79 (3H,s,18-Me) , δ0.87 (3H,s,19-Me) , δ1.12 (3H,d,21-Me) , δ1.60 (3H,d,Me of Rha), δ3.26 (OMe) , δ4.78 (1H,d,H-1of Gal), 4.82 (1H,s,H-1 of Glc), δ4.96 (1H,d,H-1 of Glc), δ4.98 (1H,s,H-1of Glc), δ5.11 (1H,H-1 of Rha). CI-MS ; m\z 1092.7 [M$^+$], 1058.9 [M$^+$-OMe], 947 [M$^+$-Rha], 917 [M$^+$-(Glc+O)],754.4 [M$^+$-Rha-Glc - OMe], 592.6 [M$^+$ - Rha - 2 Glc - OMe] and 429.3 [M$^+$ - Rha - 2Glc – Gal - OMe]. ^{13}C-NMR see tables 1 and 2 .

MOLLUSCICIDAL ASSAY

Biomphalaria alexandrina snails, the intermediate host of *Schistosoma mansoni* in Egypt were collected from the canals in Abou-Rawash,Giza Governorate .The snails have been maintained in dechlorinated tap water in the laboratory conditions (Temperature 25 ± 2 °C and pH 7.7-7).Tests were performed in duplicate using ten snails for each test. Compounds were initially dissolved in small amount of absolute ethanol then desired dilutions were prepared with dechlorinated tap water. The snails were exposed to different dilutions for 24 hours followed by 24 hours in dechlorinated tap water as recovery period Procedures and statistical analysis of the data were carried out according to the WHO and Litchfield and Wilcoxon protocol (9,10) .

ACID HYDROLYSIS

Each saponin (20 mg) was refluxed with 2N HCl –MeOH (1 : 1 ; 50 ml) for 5 hours . The reaction mixture was diluted with water and extracted with chloroform . The chloroformic extract was evaporated to dryness and the aglycone part in each case was identified by TLC analysis with authentic samples using solvent system C_6H_6 : EtOAc ; 80 : 20. The aqueous layer was neutralized with $NaHCO_3$,filtered and concentrated under reduced pressure .The residue was extracted with pyridine and filtered. The pyridine extract was concentrated and dissolved in 10 % isopropanol and examined by PC using solvent system n-BuOH : AcOH :H_2O ; 4 : 1 :5 against sugar samples .

Saponins **I** and **II** gave yamogenin as aglycone part m.p. 200-201° C [Lit.201°C(11,12)]. IR (KBr} ν max cm^{-1} 3401, 2930,1645, 1445, 920, 898 and 860. [920 > 898, 25S – spiroketal]. Saponins **III-V** yielded gitogenin m.p.217-218°C [Lit 217°C (13,14).IR (KBr) ν max Cm^{-1} 4310, 2935, 2870, 1443, 1175, 1045, 972,919,895 and 700 [895 > 919 , 25R-spiroketal] .

RESULTS AND DISCUSSION

The deffated methanolic extract of the dried leaves of *Y. elephantipes* was suspended in water and successively extracted with chloroform, ethyl acetate and n-butanol. The butanol-soluble fraction was subjected to silica Gel column using gradient elution $CHCl_3$, $CHCl_3$-MeOH mixtures and pure MeOH and the column products were monitored by TLC. The similar fractions were collected and rechromatographed on preparative TLC and centrifugal chromatography device and the resulted saponins were purified over Sephadex LH-20 columns using MeOH as eluent .The structures of the pure saponins were elucidated using IR,^{1}H-NMR,^{13}C-NMR and CI-MS in addition to identification of the products of acid hydrolysis of each saponin .

Saponin **I** was obtained as white powder, its IR spectrum showed strong absorptions for hydroxyl groups at cm^{-1} 3408 and spirostanol at 972, 925 and 892 [Intensity 925 > 892 ; 25S-spiroketal type](15,16). The ^{1}H-NMR spectrum contained signals for an olefinic proton at δ 5.32 ,four typical steroid methyl groups at δ 0.71,0.82,1.01 and 1.11 as well as three anomeric protons at δ 4.84, 4.86 and 5.11(17,18). The ^{13}C-NMR spectrum exhibited a total 27 carbons arising from the aglycone moiety and seventeen carbons arising from the sugar moiety. The signals at δ109.8, 31.5 and 66.7 were assignated to the C-22,C-23,and C-26 positions on the spirostan skeleton (17,18). CI-MS spectrum showed a molecular ion peak at 869 [M^+] and fragment ions at 737.2 [M^+-Xyl], 575 [M^+-Xyl-Glc] and 413 [M^+-Xyl- 2 Glc] corresponding to the loss of one xylosyl unit and two glucosyl units .Its ^{13}C-NMR spectrum displayed three anomeric carbon signals at δ 100.9,105.13 and 104.5. Also ,C-3 of the aglycone moiety was shifted at downfield δ 78.2 suggesting that the sugar chain must be attached at C3-OH of the aglycone part(19,20). The signals of C-2 and C-3 of the inner glucose were noticed at downfield δ 80.1 and 87.6. This reflected that the two carbons are positions of the attachments of the terminals glucose and xylose units (20,21). On acid hydrolysis, saponin **I** gave D-glucose and D-xylose and yamogenin as aglycone part. Both the sugar units and the aglycone part was compared with authentic samples. Saponin **1** exhibited a strong molluscicidal activity against *B. alexandrina* snails (LC_{90} = 4 ppm) indicating its monodesmosidic nature(22,23). Thus the structure of saponin **I** was elucidated as 3-O-β-D-xylopyranosyl - (1→2)[- β-D-glucopyranosyl-(1→3)]- β-D-glucopyranoside yamogenin.

Saponin **II** was assumed to be a furostanol saponin on the basis of the positive coloration with Ehrlich reagent (24). It showed strong absorptions in the IR spectrum due to a hydroxyl groups at 3401 Cm^{-1} but not for a spiroketal function suggesting a furostanol glycoside structure(24,25). Acid hydrolysis of saponin **II** gave D-glucose and D-xylose in addition to yamogenin as aglycone part. In CI-MS spectrum, a peak at m|z 1023.9 was consistent with the molecular weight of the compound. Other fragment ions at m\z 871.4 [M^+-Xyl-H_2O],709.1[M^+-Xyl-Glc-H_2O], 579.6 [M^+-Xyl-2Glc-H_2O] and 415.6 [M^+-Xyl-3Glc-H2O] suggesting that saponin **II** was tetrasaccharide glycoside (25,26). This was supported by presence of four anomeric proton signals at δ4.82,4.86,4.98 and 5.17 in the ^{1}H-NMR and four anomeric carbon signals at δ 100.77,105.05,104.2 and 104.9 in the ^{13}C-NMR spectrum (26,27).The characteristic signal of C-22 hydroxylated furostane saponin was noticed at δ112.2 and the signal of C-3 was shifted at downfield δ 78.1 indicating that the sugar chain must be linked at this position . Furthermore , the points of attachments of the sugar units were determined through the shifting of C-2 and C-3 of the inner glucose at downfield δ 79.8 and 87.9 in ^{13}C-NMR spectrum which indicated that C2-OH and C3-OH of the inner glucose were positions of attachments of the terminal glucose and xylose units(25-27). Biological test revealed that saponin II had no molluscicidal activity up to 50 ppm indicating its bidesmosidic nature(22,23). Therefore , the structure of saponin **II** was determined as 3-O-[β-D-xylopyranosyl-(1→2) - β- D- glucopyranosyl-(1→3)], 26-β-D- glucopyranoside (25 S) – furost - 5-ene-3, 22, 26 - triol

Saponin **III** showed hydroxyl absorption band at 3397and characteristic absorption band of 25R –spiroketal ν max cm^{-1} at 921,898,864 in the IR spectrum where the intensity of band at ν max cm^{-1} 898 was greater than band at ν max cm^{-1} 921 (15,16). Acid hydrolysis of saponin **III** gave four monosaccharide units which were identified as D-galactose, D-glucose, L-rhamnose and D-xylose by direct comparison with authentic sugars. Also, the aglycone part was confirmed as gitogenin by direct comparison with authentic sample.CI-MS spectrum of saponin **III** showed a molecular ion peak at m\z 1031.7 [M^+],and other fragment ions at 887.8 [M^+-Rha], 755.5 [M^+-Rha-Xyl], 593.4 [M^+-Rha - Xyl - Glc] and 431 [M^+-Rha-Xyl-Glc-Gal] indicating that saponin **III** was a gitogenin tetraglycoside(14,28). In the ^{13}C-NMR spectrum, the signals of the aglycone part were superimposed on those of gitogenin except for C-3 which shifted at downfield δ 84.4 due to glycosylation shift caused by sugar bonding to the C-3 hydroxyl of gitogenin(28,29). The ^{1}H-NMR spectrum showed signals for four methyl groups at δ 0.70,0.81,0.98 and 1.11 and signal due to methyl group of 6-deoxyhexopyrane at δ1.62 (27,28). In the ^{13}C-NMR spectrum,it was observed that the signal of C-4 of the galactose was remarkably displaced at downfield to resonate at δ 80.2 suggesting that this carbon was the position of the sugar chain linkage .Also, the signals of C-2 and C-3 of the inner glucose were shifted at downfield at δ 79.9 and 87.5 indicating that the terminal sugar units ;xylose and glucose were linked at C-2 and C-3 of the inner glucose(14,28,29). Saponin III exhibited high molluscicidal potency against *B. alexandrina* snails (LC_{90} = 9 ppm) showing that it was monodesmosidic saponin(22,23). Accordingly, the structure of saponin **III** was elucidated as 3- O- α - L - rhamnopyranosyl-(1→2) - [β - D – xylopyranosyl - (1→3)] - β - D – glucopyranosyl - (1→4) - β - D-galactopyranoside gitogenin.

Saponin **IV** was predicated to be a glycoside of (25R)-spirostanol from its IR spectrum at ν max cm^{-1} 947, 919, 900 and 866 [Intensity 900 > 919] (15,16). The ^{1}H-NMR spectrum showed the characteristic signals of the four methyl groups at δ 0.69,0.74,0.80 and 1.19 beside three signals of anomeric protons of sugar residues at δ 4.76, 4.80, 4.92 and 5.12(14,29). CI-MS mass spectrum exhibited the important fragment ions at m\z 1049 [M^+] , 917 [M^+-Xyl], 755.4 [M^+-Xyl-Glc], 593.6 [M^+-Xyl-2Glc] and 431.3 [M^+-Xyl-2 Glc-Gal] suggesting this compound had four monosaccharide ; one xylosyl , two glucosyl and one galactosyl .This was confirmed by the product of acid hydrolysis which was identified as D-xylose, D-glucose and D-galactose by direct comparison with authentic sugars. Also, in the ^{13}C-NMR spectrum, four anomeric carbon signals were appeared at δ 101.9,103.4,104.6 and 105.04 (29,30). The signals of the aglycone part were identical to the signals of gitogenin except for C-3 which shifted at downfield at δ84.3 reflecting the sugar chain was linked at C3-OH of the aglycone part (14,29).The signal of C-4 of the galactose was shifted at downfield δ 80.3 suggesting that the inner glucose was linked at C4-OH of galactose unit. In the same time, the signals of C-2 and C-3 of the inner glucose were shifted at downfield at δ 79.80 and 87.1 reflecting that the two carbons were the positions of attachments of the two terminals sugar units ;xylose and glucose(28-30). Saponin **IV** was high molluscicidally active (LC_{90} =7 ppm). Therefore , the structure of saponin **IV** was determined as 3-O-β-D- xylopyranosyl-(1→ 3)-[β- D – glucopyranosyl - (1→2)]- β - D – glucopyranosyl - (1→4)- β - D-galactopyranoside gitogenin.

Saponin **V** showed absorption due to hydroxyl groups at ν max cm^{-1} 3409 but no spiroketal side chain absorption in the IR spectrum and was positive to the Ehrlish reagent suggesting it is a furostanol glycoside(15,16,24). The presence of the characteristic ^{1}H and ^{13}C-NMR signals at δ H 3.26 (3H,s) and δ C 111.8 (C) and 46.5 (OMe) were in favor of a 22-methoxy furostanol saponin(27-29). CI-MS spectrum showed a molecular ion peak at m\z 1092.7 [M$^+$] and the other fragmentation peaks appeared at m\z 1058.9 [M$^+$-OMe] , 947[M$^+$-Rha], 917[M$^+$- (Glc-OMe)], 754.4 [M$^+$-Rha-Glc-OMe], 592.6 [M$^+$-Rha-2Glc-OMe] and 429.3 [M$^+$ - Rha - 2Glc – Gal - OMe]. This confirmed that saponin **V** contain four monosaccharide units. Acid hydrolysis of saponin **V** revealed that the aglycone part was gitogenin which was identified by direct comparison with authentic sample and the sugar moiety was identified as D-galactose, D-glucose and L-rhamnose. The ^{1}H-NMR spectrum exhibited five anomeric proton signals at δ 4.78, 4.82, 4.96, 4.98 and 5.11. This was supported by presence of five anomeric carbon signals in ^{13}C-NMR at δ 102.5,103.6,104.3 , 100.2 and 104.2 (28-30). Biological test of saponin **V** exhibited that it was inactive against *B. alexandrina* snails up to 50 ppm showing its furostanol skeleton nature (22,23). In addition to the characteristic furostanol carbon signals and five anomeric carbons for the sugar moieties in the ^{13}C-NMR spectrum,the points of attachments of the sugar residues to the aglycone also appeared where the signal assignated to glycosidated C-26 and C-3 was shifted at downfield δ 74.2 and 84.1 due to the glycosidation at these positions(30,31). The interglycosidic linkages between the sugar units were confirmed by ^{13}C-NMR spectrum ; C-4 of galactose was shifted at downfield δ 79.8 reflecting that the inner glucose was linked at C4-OH of the galactosyl unit. Also the chemical shifts of C-2 and C-3 of the inner glucose at downfield δ 80.1 and 86.9 indicating that the two terminal sugar residues glucose and rhamnose were linked at C2-OH and C3-OH of the inner glucosyl (29,31). Thus saponin **V** was 26 - O - β - D - glucopyranosyl - 22-O-methyl (25R) - 5 - furostan - 2,3,26 - tetrol- 3 - O-[α-L-rhamnopyranosyl - (1→3)] – β – D – glucopyranosyl -(1→2)- β-D-glucopyranosyl-(1→4)- β-D-galactopyranoside.

This study is in full agreement with the previous studies(32, 33) which cleared that the furostanol glycosidess **II** and **V** undergo elimination of the sugar molecule from C-26 and the ring F of the aglycone part have been closed by the action of the acid hydrolysis to yield spirostanol sapogenins .

Table (1): ^{13}C-NMR spectral data of the aglycone parts of saponins **I-V** (in DMSO-d_6; as internal standard)

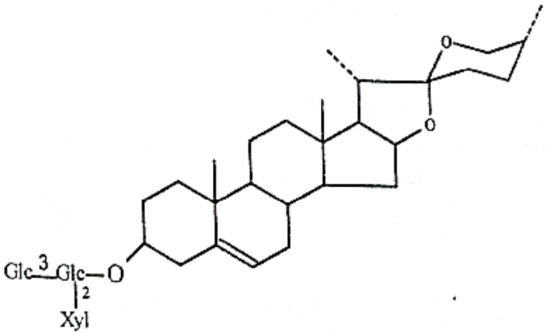
Carbon No.	**I**	**II**	**III**	**IV**	**V**
1	37.3	37.21	45.4	45.2	45.1
2	30.4	30.3	70.18	70.1	69.7
3	78.2	78.1	84.4	84.3	84.1
4	38.8	39.1	33.29	33.8	33.6
5	140.7	140.42	44.6	44.2	44.3
6	121.5	121.15	28.81	27.9	27.7
7	32.3	32.5	31.46	32.1	31.8
8	31.9	31.4	34.6	34.3	34.3
9	50.2	50.3	54.46	54.1	53.9
10	37.3	37.1	36.88	36.51	36.5
11	21.1	21.08	21.4	21.3	21.1
12	39.8	39.5	40.19	39.8	40.0
13	40.3	40.41	40.57	40.2	40.7
14	56.5	56.3	56.49	56.5	56.2
15	32.3	32.1	32.4	32.4	31.6
16	81.2	81.1	80.45	80.7	80.5
17	63.1	63.2	63.0	63.2	63.3
18	16.4	16.3	16.6	16.4	16.2
19	19.3	19.6	13.4	13.2	13.2
20	41.8	41.83	42.1	41.2	40.4
21	16.5	16.3	14.92	14.8	16.1
22	109.8	112.2	109.4	109.9	111.8
23	31.5	31.4	31.42	31.4	31.8
24	29.8	28.4	28.85	28.9	27.2
25	30.2	34.5	30.7	30.4	33.1
26	66.7	75.2	65.85	66.2	74.2
27	17.5	17.3	17.2	17.4	16.5
OMe	-	-	-	-	46.5

Table (2): ^{13}C-NMR spectral data of the sugar moieties of saponins **I-V** (in DMSO-d_6; as internal standard)

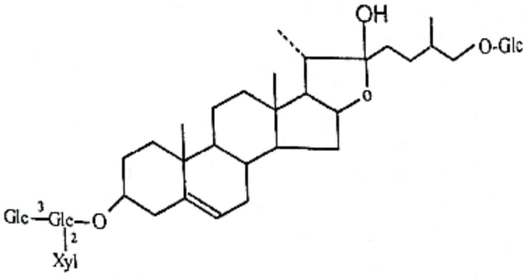
Carbon No.	I	II	III	IV	V
	3-O-Glc	3-O-Glc	3-O-Gal	3-O-Gal	3-O-Gal
1	100.9	100.77	102.2	101.9	102.5
2	80.1	79.8	73.1	73.2	73.3
3	87.6	87.9	75.4	75.6	75.3
4	70.6	70.1	80.2	80.3	79.8
5	77.4	77.8	76.7	76.6	77.1
6	62.3	62.4	61.17	61.3	61.2
	Xyl-^{2}Glc	Xyl-^{2}Glc	Glc-^{4}Gal	Glc-^{4}Gal	Glc-^{4}Gal
1	105.13	105.05	103.57	103.4	103.6
2	75.2	75.1	79.9	79.8	80.1
3	78.5	78.3	87..5	87.1	86.9
4	70.8	70.5	70.1	70.3	70.2
5	67.8	67.3	78.1	77.8	78.2
6		62.3	62.1	62.1	62.5
	Glc-^{3}Glc	Glc-^{3}Glc	Rha-^{2}Glc	Glc-^{3}Glc	Glc-^{3}Glc
1	104.5	104.2	101.9	104.6	104.3
2	75.2	74.1	72.4	75.1	75.2
3	76.4	76.2	72.6	78.5	78.6
4	71.5	71.6	74.5	71.2	71.4
5	78.1	77.9	69.6	78.1	78.2
6	62.2	62.3	17.8	62.1	62.3
			Xyl-^{3}Glc	Xyl-^{3}Glc	Rha-^{2}Glc
1			105.4	105.04	100.2
2			75.1	75.3	72.3
3			77.9	78.1	72.5
4			69.6	70.2	74.3
5			67.2	67.3	17.6
		26-O-Glc			26-O-Glc
1		104.9			104.2
2		75.9			75.3
3		78.4			78.2
4		71.4			70.9
5		78.5			78.3
6		62.4			62.6

Table (3): Molluscicidal activities of saponins **I-V** against *Biomphalaria alexandrina* after 24 hours exposure.

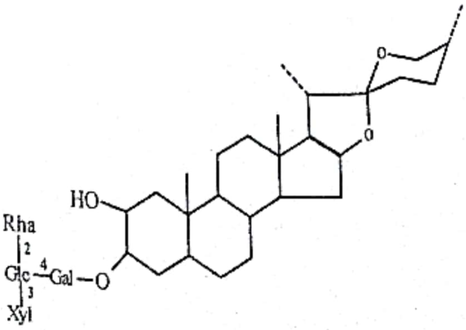
Saponin	LC_{50} (ppm)	LC_{90} (ppm)	S
I	2 (1.098-3.873)	4	1.22
II	-ve up to 50		
III	5 (3.631-7.142)	9	1.12
IV	4 (2.898-6.341)	7	1.30
V	-ve up to 50		



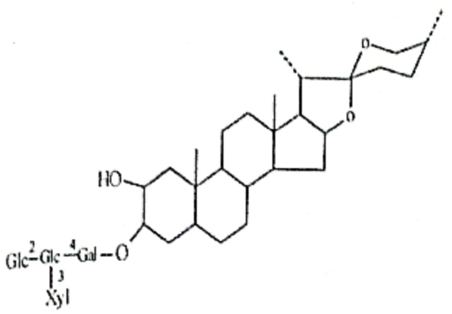
(I)



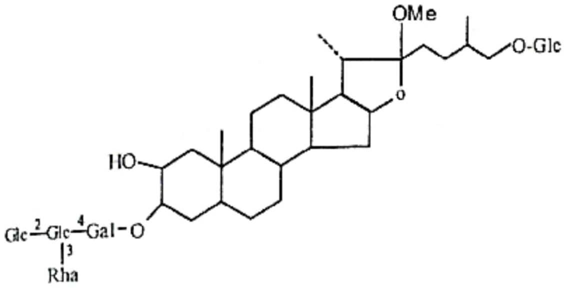
(II)



(III)



(IV)



(V)

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صابونينات يوكا اليفانتيبس

وتقييمهم كمبيدات للقواقع

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-أمكن فصل خمسة مركبات صابونينية من المستخلص الميثانولي لنبات يوكا اليفانتيبس بالطرق الكروماتوجرافية المختلفة وأمكن تحديد التركيب الكيميائي للمركبات المفصولة باستخدام التحليلات الطيفية المختلفة بالاضافة الي بعض الطرق الكيميائية ٠

- بتجريب الصابونينات الخمس المفصولة كمبيدات لقواقع بيومفلاريا الكسندرينا (العائل الوسيط لطفيل البلهارسيا المعوية في مصر) وضح أن المركبات الأول والثالث والرابع لهم قدرة ابادية عالية ضد القواقع بينما المركبات الثاني والخامس لم تظهر أي فاعلية ضد القواقع حتى تركيز ٥٠ جزء في المليون ٠