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Original Research Article

Chemical constituents from the leaves of *Fraxinus excelsior* L., *Senna sulfurea* (Collad.) H. S. Irwin et Barneby and *Prosopis cineraria* (L.) Druce

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ABSTRACT

Fraxinus excelsior L. (Oleaceae) is used to treat diarrhoea, dysentery, jaundice, joint pain, malaria, sores, swelling and wounds. The leaves of *Senna sulfurea* (Collad.) H. S. Irwin et Barneby (Leguminosae) are effective to cure blennorrhagia, diabetes, dysentery, gonorrhea and skin diseases. *Prosopis cineraria* (L.) Druce, (Fabaceae) is taken to alleviate anxiety, asthma, bronchitis, dysentery, dyspepsia, fever, leprosy, leucoderma, muscle tremors, piles, rheumatism and tremors. Our study was planned to isolate chemical constituents of the methanolic extracts obtained from the leaves of *F. excelsior*, *S. sulfurea* and *P. cineraria* and to characterized their structures. The air-dried plant materials were exhaustively extracted with methanol separately in a Soxhlet. The concentrated methanolic extracts were adsorbed on silica gel (60-120 mesh) for the preparation of slurries. The dried slurries were chromatographed over silica gel columns individually packed in petroleum ether. The columns were eluted with petroleum ether, chloroform and methanol successively in order of increasing polarity to isolate a variety of phytoconstituents. Phytochemical investigation of the leaves of *F. excelsior* afforded (*Z,Z,Z*)-*n*-tetratriacont-3,5,15-triene (**1**), *n*-hexatriacontane (**2**), (*Z,Z,Z*)-*n*-octatriacont-11,13,20-triene (**3**), phytanic acid (3,7,11,15-tetramethylhexadecanoic acid, **4**), 26-hydroxystigmasterol-18-oic acid (**5**) and α-L-xylose (**6**). The leaves of *S. sulfurea* furnished isoliquiritigenin (**7**) and 4-methoxy-α-L-xylopyranosyl-(3→1′)-*O*-α-L-4′-methoxyxylopyranoside (di-4-methoxy-α-L-xyloside, **8**). The leaves of *P. cineraria* on subjection to silica gel column chromatography led to isolate glyceryl-1-oleioyl-2-myristioyl-3-*O*-hydroxydihydrocinnamate (**9**), 2,3,4-trihydroxybenzyl *n*-hexadecanyl ether (**10**) and salicyloyl *O*-α-D-glucopyranosyl-2′-oleate (**11**). Their structures were established on the basis of spectral data analysis and chemical reactions.

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1. Introduction

Fraxinus excelsior L., syn. *F. acutifolia* Dippel , *F. aurea* Willd., *F. heterophylla* Vahl, *F. stricta* Beissner (Oleaceae), known as European ash, common ash, weeping ash, bird's tongue and kum, is distributed throughout Europe and cultivated as an ornamental plant in New Zealand, United States and Canada. It is a large tree, up to 40 m tall, with domed crown, ascending branches, bark smooth, pale grey, thick, fissured; leaves compound, 9-13 leaflets, odd pinnate, serrated and stalkless; flowers open before the leaves unfold; seeds flattened, 2-5 cm long, in bunches, ripen individually in oval-shaped samaras. (Kerr, 1998; Anonymous, 2012). The ash bark is used to treat arthritis, diarrhoea, dysentery, gout, rheumatism, sores, swelling and wounds. It is substituted for quinine to cure malaria. The leaves are taken as a diuretic, laxative and recommended against fever, rheumatism, gout, oedema, stones, constipation, liver problems, jaundice, nephrolithiasis, kidney pain, oedema, cervical pain, worm infestations, intoxications, urinary stones and worm infestation; and externally

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for leg ulcers and wounds (Nadkarni, 1982; Gaedcke, 1993; Bruneton, 1999; Duke et al., 2002; Gruenwald et al., 2007; Kostova and Iossifova, 2007; Tahirović and Bašić, 2016). The plant sap is useful as an antidotes for snake bites. The previous phytochemical studies on the leaves evidenced the presence of coumarins coumarins, iridoids, seco-iridoids, rutin, kaempferol and quercetrin-3-*O*-glucoside, their respective 3-*O*-rhamnoglucosides, β-sitosterol, betulin, betulinic acid and ursolic acid (Carnat et al., 1990; Damtoft et al., 1992; Gaedcke, 1993; Iossifova et al., 1997; Egan et al., 2004; Gruenwald et al., 2007; Kostova and Iossifova, 2007). Ferulic, caffeic, *p*-coumaric, *p*-hydroxybenzoic, protocatehuic, sinapic, syringic and vanillic acids, hentriacontane, nonacosane, tetratriacontane, tannins and mannitol were found in different parts of *F. excelsior* (Carnat et al., 1990; Gaedcke, 1993; Oddo et al., 2002). The seeds afforded seco-iridoids excelsides A and B, muzhenide, GI3, GI5, ligstroside, oleoside 11-methyl ester, oleoside dimethyl ester, 1‴-*O*-β-D-glucosyl formoside and salidroside (Bai et al., 2010). Phenolic compounds were detected in the heartwood (Sanz et al., 2012).

Senna sulfurea (Collad.) H. S. Irwin et Barneby, syn., *Cassia glauca* Lam., *C. arborescens* Vahl, *C. enneaphylla* Wight et Arn. and *Senna arborescens* (Vahl) Roxb. (Leguminosae), known as glaucous cassia, glossy sulphur-flowered senna, kalamona, scrambled eggs and smooth senna, is distributed in India, Sri Lanka, south eastern Asia, Australia, Polynesia, Gabon and China. It is commonly planted as an ornamental plant due to its beautiful flowers. It is up to 3 m high, evergreen, perennial shrub or small tree, with long linear, acute, curved leaves; inflorescence at axillary raceme, yellow flowers; flat strap shaped pods, black shiny seeds. (Quattrocchi, 2012). The leaves mixed with milk and sugar are taken to cure blennorrhagia. The bark and leaves are useful to relieve diabetes, dysentery and gonorrhea (Kiritikar and Basu, 1990; Quattrocchi, 2012). This plant is also a good pollution tolerant and reduces chemical pollutants from the atmosphere (Warrier et al., 1996). The flowers and pods are purgative; the pods are used as an antiseptic to subside skin diseases (Quattrocchi, 2012). The stem contained chyrosphanol, physcion, stearic acid, β-sitosterol and its 3-*O*-D-glucoside (Hemlata and Kalidhar, 1994). The leaves yielded di-(2-ethyl hexyl) phthalate, apigenin, luteolin, quercetin, its 3-glycosides, kaempferol 3-*O*-rutinoside, D-(+)-pinitol and rutin (El-Sayed et al., 2013; Kittur et al., 2015). The pods afforded 5,7-dihydroxy-4′-methoxyflavono-3-*O*-β-D-galactoside, chrysophenol, physcion, kaempferide and quercetin. (Rai et al., 1997). The seeds yielded methyl esters of fatty acids. (Kumar et al., 2013).

Prosopis cineraria (L.) Druce, syn. *Adenanthera aculeate* Roxb., *Mimosa cineraria* L., *Prosopis spicata* Burm. f. (Fabaceae), called as shami, khejri, kandi, jand, Indian mesquite and sponge tree, is distributed in Afghanistan, India, Iran, Oman, Pakistan, Sri Lanka, Saudi Arab and Yemen. It is a small, 3-5 m tall tree, with bipinnate leaves, 7-14 leaflets on each of one to three pinnae; thorny branches along the internodes; small, creamy-yellow flowers; seeds in pods. The bark is considered as an abortifacient, anthelmintic, laxative, refrigerant, tonic and vermifuge, used to treat anxiety, asthma, bronchitis, dysentery, dyspepsia, fever, leprosy, leucoderma, muscle tremors, piles, rheumatism and tremors (Kirtikar and Basu, 1984). A leaf paste is applied to cure boils, blisters, sores and mouth ulcers. Smoke from the leaves is suggested for eye troubles (Nadkarni, 2000). The flowers are taken as an antidiabetic and mixed with sugar are given to prevent miscarriage (Anonymous, 2003). The plant material is used to treat snake bite and scorpion sting. The wood ash is rubbed over the skin to remove hair. (Janbaz et al., 2012). A pod extract is used to relieve earache, toothache and fractured bone pain (Ghazanfar and Alsabahi, 1993). The whole plant contained methyl heptacosanoate, heneicosanoic acid, 4-hydroxybenzoic acid, methyl 4-hydroxycinnamate, methyl 2-methoxy-5-hydroxycinnamate, methyl 2,5-dihydroxy-cinnamate and 1-O-coumaroylglycerol (Khan et al., 2006). The leaves possessed phytosterols, spicigerine, hentriacontane, methyl docosanoate, diisopropyl-10,11-dihydroxyicosane-1,20-dioate, tricosan-1-ol and 7,24-tirucalladien-3-one. (Malik and Kalidhar, 2007; Garg and Mittal, 2013). The roots afforded methyl tritriacontanoate, β-sitosterol, diethyl 2,3,6,7-tetraethoxydodecan-1,12-dioate and β-glucose (Malik and Kalidhar, 2007). The seeds furnished fatty acids, prosogerins C, D and E, gallic acid, patuletin, patulitrin, luteolin, rutin and galactomannan (Sharma and Soni, 1994; Gangal et al., 2009; Garg and Mittal, 2013). The immature pods yielded 3-benzyl-2-hydroxy-urs-12-en-28-oic acid, maslinic acid 3-glucoside, linoleic acid, prosophylline, 5,5′-oxybis-1,3-benzene diol, 3,4,5-trihydroxycinnamic acid 2-hydroxyethyl ester and 5,3′,4′-trihydroxyflavanone 7-glucoside (Liu et al., 2012). The flowers contained patulitrin, β-sitosterol, spicigerine and prosogerins A and B (Garg and Mittal, 2013). Keeping in view the high reputation and application of *Fraxinus excelsior*, *Senna sulfurea* and *Prosopis cineraria* in the indigenous medicinal systems, it has been aimed to carry out isolation and characterization of chemical constituents from the leaves of these plants.

2. Experimental

2.1. General procedures

Melting points were recorded using one end open capillary tubes on a thermoelectrically heated melting point M-560 apparatus (Perfit, India) without correction. UV spectra were determined with Lambda Bio 20 spectrophotometer (Perkin Elmer, Schwerzenbach, Switzerland) in methanol. The IR spectra were recorded by using KBr pellets with Jasco FT/IR-5000 Spectrometer (FTS 135, Hong Kong). The ^{1}H (400 MHz)

and ^{13}C (100 MHz) NMR spectra were recorded on Bruker DRX Spectrometer (Rheinstetten, 2 Germany) using $CDCl_3$ and DMSO-d_6 as solvents and TMS (Fluka analytical, Sigma-Aldrich, Netherland) as an internal standard. Mass spectrometric detection was carried out on (Q-TOF-ESI) (Waters Corp., UK) instrument with a +ve and -ve ESI techniques. Column chromatography was performed on silica gel (Qualigens, Mumbai, India) with 60-120 mesh particle size and petroleum ether, chloroform, methanol and other solvents used were purchased from Merck Specialties (E. Merck, Pvt. Ltd. New Delhi, India). The purity of the isolated compounds was checked on precoated TLC plates with Silica gel 60 F_{254} (Merck, 0.25 mm) and the spots were visualized by exposure to iodine vapors or under UV radiations and spraying with ceric sulfate solution.

2.2. Plant materials

The leaves of *Fraxinus excelsior*, *Senna sulfurea* and *Prosopis cineraria* were collected from the Jahan Panah garden of South Delhi and authenticated by Prof. M.P. Sharma, Taxonomist, Department of Botany, Jamia Hamdard, New Delhi. Their voucher specimens numbers (PRL/JH/2015/04), (PRL/JH/2016/21) and (PRL/JH/2015/12), respectively, are preserved in the herbarium of the Department of Pharmacognosy and Phytochemistry, Jamia Hamdard, New Delhi.

2.3. Extraction and isolation

One kilogramme (1.0 kg) each of the leaves of *F. excelsior*, *S. sulfurea* and *P. cineraria* were coarsely powdered and extracted separately and exhaustively with methanol in a Soxhlet apparatus. The extracts were concentrated under reduced pressure to get dark brown masses, 123.4 g, 132.6 g and 116.2 g, respectively. Small portion of each extract was analyzed chemically to determine the presence of different chemical constituents. The dried extract (100 g each) was dissolved in a minimum quantity of methanol and adsorbed on silica gel (60-120 mesh) for the preparation of slurries. Each slurry was dried in air and chromatographed individually over silica gel columns (1.6 m x 16 mm x 2 mm) packed in petroleum ether. Each column was eluted successively in increasing order of polarity in various combinations with petroleum ether, petroleum ether-chloroform (9:1, 3:1, 1:1, 1:3, *v/v*), chloroform, chloroform-methanol (19.9: 0.1; 99: 1; 97: 3; 19: 1; 93: 7; 9: 1; 17: 3; 4:1; 3: 1; 3: 2; 2: 3, *v/v*) and methanol. The fractions were collected separately and matched by TLC to check homogeneity. Similar fractions having the same R_f values were combined and crystallized. The isolated compounds were recrystallized to get the following pure compounds:

2.3.1. Isolation of phytoconstituents from the leaves of *Fraxinus excelsior*

2.3.1.1. *n*-Tetratriacont-3,5,15-triene (**1**)

Elution of the column with petroleum ether produced pale yellow semisolid mass of **1**, yield 158 mg, UV λ_{max} (MeOH): 211 nm; IR γ_{max} (KBr): 2956, 2848, 1637, 1483, 1376, 1247, 1170, 723 cm^{-1}; ^1H NMR ($CDCl_3$): δ 5.26 (1H, m, *w1/2*=8.6 Hz, H-4), 5.17 (1H, m, *w1/2*=9.1 Hz, H-5), 5.14 (1H, m, *w1/2*=8.2 Hz, H-6), 5.11 (1H, m, *w1/2*=8.8 Hz, H-15), 5.08 (1H, m, *w1/2*=7.6 Hz, H-3), 5.05 (1H, m, *w1/2*=8.1 Hz, H-16), 2.13 (2H, m, H_2-7), 2.09 (2H, m, H_2-17), 2.04 (2 H, m, H_2-2), 2.01 (2 H, m, H_2-14), 1.98 (2 H, m, H_2-2), 1.75 (2H, m, CH_2), 1.63 (4 H, brs, 2 x CH_2), 1.29 (36 H, br s, 18 x CH_2), 0.91 (3 H, t, *J*=6.2 Hz, Me-1), 0.87 (3 H, t, *J*=6.5 Hz, Me-34); ^{13}C NMR ($CDCl_3$): δ 134.96 (C-4), 134.84 (C-5), 131.29 (C-6), 124.47 (C-15), 124.30 (C-16), 124.26 (C-3), 39.75 (C-7), 39.72 (C-14), 37.19 (CH_2), 33.75 (CH_2), 31.94 (2 x CH_2), 29.87 (CH_2), 29.78 (CH_2), 29.73 (4 x CH_2), 29.67 (2 x CH_2), 29.55 (3 x CH_2), 29.37 (2 x CH_2), 29.32 (CH_2), 29.27 (CH_2), 28.30 (CH_2), 26.77 (CH_2), 26.68 (CH_2), 25.71 (CH_2), 22.72 (CH_2), 16.07 (Me-1), 14.12 (Me-34); ESI MS *m/z* (rel. int.): 472 $[M]^+$ ($C_{34}H_{64}$) (32.3), 443 (48.2), 391 (4.8), 279 (6.2), 253 (5.1).

2.3.1.2. *n*-Hexatriacontane (**2**)

Further elution of the column with petroleum ether gave colorless powder of 2, 146 mg, m.p. 75 -76 ºC, UV λ_{max} (MeOH): 209 nm; IR γ_{max} (KBr): 2954, 2845, 1467, 1367, 1255, 1176, 726 cm^{-1}; ^1H NMR ($CDCl_3$): δ 2.14 (2H, m, CH_2),1.62 (2 H, m, CH_2), 1.31 (2 H, m, CH_2), 1.26 (32 H, br s, 16 x CH_2), 0.88 (3 H, t, *J*=6.4 Hz, Me-1), 0.83 (3 H, t, *J*=6.5 Hz, Me-36); ^{13}C NMR ($CDCl_3$): δ 31.89 (CH_2), 29.78 (26 x CH_2), 25.34 (CH_2), 22.69 (CH_2), 14.18 (Me-1), 14.13 (Me-36); ESI-MS *m/z* (rel. int.): 506 $[M]^+$ ($C_{36}H_{74}$) (16.2).

2.3.1.3. *n*-Octatriacont-11,13,20-triene (**3**)

Further elution of the column with petroleum ether afforded yellow semisolid mass of **3**, 121 mg, UV λ_{max} (MeOH): 218 nm; IR γ_{max} (KBr): 2925, 2853, 1638, 1463, 1378, 994, 721 cm^{-1}; ^1H NMR ($CDCl_3$): δ 5.86 (1H, m, $w_{1/2}$=8.7 Hz, H-12), 5.74 (1H, m, $w_{1/2}$=9.2 Hz, H-13), 5.16 (1H, m, $w_{1/2}$=8.1 Hz, H-14), 5.09 (1H, m, $w_{1/2}$=6.6 Hz, H-11), 5.04 (1H, m, $w_{1/2}$=9.1 Hz, H-20), 4.99 (1H, m, $w_{1/2}$=8.7 Hz, H-21), 2.05 (2H, m, H_2-2), 2.01 (2H, m, H_2-10), 1.99 (2 H, m, H_2-15), 1.97 (2 H, m, H_2-19), 1.95 (2 H, m, H_2-22), 1.68 (2H, m, CH_2), 1.61 (2H, brs, CH_2), 1.38 (2H, m, CH_2), 1.35 (2H, m, CH_2), 1.33 (2H, m, CH_2), 1.31 (2H, m, CH_2), 1.28 (4H, m, 2 x CH_2), 1.25 (34 H, br s, 17 x CH_2), 0.86 (3 H, t, *J*=6.4 Hz, Me-1), 0.82 (3 H, t, *J*=6.5 Hz, Me-38); ^{13}C NMR ($CDCl_3$): δ 139.29 (C-12), 135.33 (C-13), 131.26 (C-14), 124.4 (C-11), 124.29 (C-20), 114.08 (C-21), 39.76 (C-2), 33.83 (C-10), 32.66 (C-15), 31.97 (2 x CH_2), 29.74 (2 x CH_2), 29.67 (10 x CH_2), 29.63 (3 x CH_2), 29.53 (CH_2), 29.28 (CH_2), 29.18 (CH_2), 28.97 (CH_2), 28.29 (CH_2), 26.78 (CH_2), 26.66 (CH_2), 25.70 (CH_2), 22.72 (CH_2), 16.04 (C-1), 14.15 (C-38); ESI MS *m/z* (rel. int.): 528 $[M]^+$ ($C_{38}H_{72}$) (36.2), 387 (34.2), 335 (5.8), 265 (21.6), 239 (6.9).

2.3.1.4. Phytanic acid (**4**)

Elution of the column with petroleum ether-chloroform (1:1) produced colorless semisolid mass of **4**, 153 mg, UV λ_{max} (MeOH): 213 nm; $[\alpha]^{25}_{D}$ -1.97º (conc. 10, $CHCl_3$); IR γ_{max} (KBr): 3357, 2932, 2870, 1695, 1457, 1386, 1281, 1032, 997, 763 cm^{-1}; ^1H NMR ($CDCl_3$): δ 2.14 (2H, dd, *J*=4.0, 10.4 Hz, H_2-2), 1.92 (1 H, m, H-3), 1.71 (1 H, m, H-7), 1.68 (2 H, m, H_2-4), 1.65 (2 H, m, H_2-5), 1.61 (2H, m, H_2-6), 1.59 (2 H, m, H_2-8), 1.57 (2 H, m, H_2-9), 1.50 (2 H, m, H_2-10), 1.45 (1 H, m, H-11), 1.36 (1 H, m, H-15), 1.25 (4 H, m, H_2-12, H_2-13), 1.08 (2 H, m, H_2-14), 0.95 (3 H, d, *J*=6.8 Hz, Me-17), 0.92 (3 H, d, *J*=6.6 Hz, Me-18), 0.84 (3 H, d, *J*=6.5 Hz, Me-19), 0.73 (3 H, d, *J*=7,2 Hz, Me-16), 0.71 (3 H, d, *J*=6.9 Hz, Me-20); ^{13}C NMR ($CDCl_3$): δ 179.83 (C-1), 55.28 (C-2), 32.73 (C-3), 39.89 (C-4), 25.17 (C-5), 36.72 (C-6), 32.75 (C-7), 37.49 (C-8), 24.58 (C-9), 37.29 (C-10), 32.87 (C-11), 37.46 (C-12), 24.98 (C-13), 39.46 (C-14), 28.07 (C-15), 22.82 (C-16), 19.87 (C-17), 19.75 (C-18), 16.42 (C-19), 22.72 (C-20); ESI MS *m/z* (rel. int.): 312 $[M]^+$ ($C_{20}H_{40}O_2$) (3.5).

2.3.1.5. 26-Hydroxystigmasterol-18-oic acid (**5**)

Elution of the column with chloroform yielded yellow crystals of **5**, recrystallized from chloroform-methanol (1:1), 157.2 mg, m. p. 249 - 251 ºC; UV λ_{max} (MeOH): 221 nm (log ε 3.2); IR γ_{max} (KBr): 3420, 3365, 3280, 2931, 2852, 1693, 1636, 1455, 1381, 1242, 1183, 1035, 764 cm^{-1}; ^1H NMR ($CDCl_3$): δ 5.25 (1H, m, H-6), 5.05 (1H, m, H-22), 5.01 (1H, m, H-23), 3.81 (1H, brm, $w_{1/2}$=18.5 Hz, H-3α), 3.22 (2H, d, *J*=7.2 Hz, H_2-26), 1.08 (3H, brs, Me-19), 0.92 (3H, d, *J*=6.1 Hz, Me-21), 0.87 (3H, d, *J*=6.0 Hz, Me-27), 0.77 (3H, t, *J*=6.5 Hz, Me-29), 2.17 - 1.12 (25 H, m, 9 x CH_2, 7 x CH); ^{13}C NMR ($CDCl_3$): δ 38.25 (C-1), 29.70 (C-2), 73.25 (C-3), 39.28 (C-4), 140.07 (C-5), 120.18 (C-6), 31.88 (C-7), 32.25 (C-8), 49.27 (C-9), 37.82 (C-10), 23.11 (C-11), 37.91 (C-12), 43.26 (C-13), 53.77 (C-14), 24.28 (C-15), 29.26 (C-16), 52.93 (C-17), 181.22 (C-18), 19.13 (C-19), 33.96 (C-20), 18.49 (C-21), 138.21 (C-22), 129.32 (C-23), 47.82 (C-24), 29.21 (C-25), 63.43 (C-26), 19.36 (C-27), 23.06 (C-28), 11.84 (C-29); ESI MS *m/z* (rel. int.): 458 $[M]^+$ ($C_{29}H_{46}O_4$) (3.8), 440 (18.2), 413 (12.7), 303 (4.7), 155 (6.1).

2.3.1.6. α-L-xylose (**6**)

Elution of the column with chloroform-methanol (4:1) afforded colourless needles of **6**, recrystallized from methanol, yield 208 mg, R_f: 0.15 (toluene -ethyl acetate-formic acid, 5:4:1.8), UV λ_{max} (methanol): 210 nm, m. p. 150 -151 ºC; $[\alpha]^{D}_{24}$ -18.7º (conc 4, H_2O); IR γ_{max} (KBr): 3390, 3296, 2935, 2841, 1617, 1460, 1384, 1317, 1082, 1020, 878 cm^{-1}; ^1H NMR (DMSO-d_6): δ 4.38 (1H, d, *J*=5.4 Hz, H-1), 4.27 (1H, dd, *J*=5.4, 5.7 Hz, H-2), 4.11 (1H, m, H-3), 3.61 (1H, m, H-4), 3.57 (1H, d, *J*=7.2 Hz, H_2-5a), 3.44 (1H, d, *J*=5.6 Hz, H_2-5b); ^{13}C NMR (DMSO-d_6): δ 100.21 (C-1), 71.28 (C-2), 69.73 (C-3), 69.65 (C-4), 63.76 (C-5); ESI MS *m/z* (rel. int.): 150 $[M]^+$ ($C_5H_{10}O_5$) (6.8).

2.3.2. Isolation of phytoconstituents from the leaves of *Senna sulfurea*

2.3.2.1. Isoliquiritigenin (**7**)

Elution of the column with chloroform-methanol (99:1) mixture afforded colourless amorphous powder of **7**; recrystallized from chloroform-methanol (1:1); 148 mg, m. p. 206 -208 ºC; UV λ_{max} (MeOH): 218, 241, 347 nm (log ε 2.8, 5.3, 4.9); IR γ_{max} (KBr): 3428, 3381, 2926, 2856, 1680, 1623, 1587, 1512, 1483, 1413, 1349, 1243, 1213, 1040, 853 cm^{-1}; ^1H NMR (DMSO-d_6): δ 8.31 (1H, d, *J*=8.7 Hz, H-6′), 8.26 (1H, d, *J*=8.7 Hz, H-8), 7.72 (2H, d, *J*=7.5 Hz, H-3, H-5), 7.66 (1H, d, *J*=8.7 Hz, H-7), 6.78 (1H, dd. *J*=2.1, 8.7 Hz, H-5′), 6.34 (1H, d, *J*=2.1 Hz, H-3′), 6.29 (2H, d, *J*=7.5 Hz, H-2, H-6); ^{13}C NMR ($CDCl_3$): δ 144.13 (C-1), 130.24 (C-2), 132.90 (C-3), 152.16 (C-4), 138.27 (C-5), 123.99 (C-6), 122.54 (C-7), 129.75 (C-8), 194.06 (C-9), 146.61 (C-1′), 157.28 (C-2′), 117.41 (C-3′), 158.88 (C-4′), 116.69 (C-5′), 118.76 (C-6′); ESI MS *m/z* (rel. int.): 256 $[M]^+$ ($C_{15}H_{12}O_4$) (2.2).

2.3.2.2. Di-4-methoxy-α-L-xyloside (**8**)

Elution of the column with chloroform-methanol (9:1) afforded colourless crystals of **8**, yield 126 mg, m. p. 202-203 ºC; IR γ_{max} (KBr): 3403, 3318, 3265, 2952, 2849, 1453, 1341, 1250, 1128, 1103, 1071, 962 cm^{-1}; ^1H NMR (DMSO-d_6): δ 4.65 (1H, d, *J*=2.8 Hz, H-1α), 4.46 (1H, dd, *J*=2.8, 4.4 Hz, H-2), 4.28 (1H, m, H-3), 3.72 (2H, m, H_2-5), 3.57 (1H, m, H-4), 4.55 (1H, d, *J*=3.0 Hz, H-1'), 4.38 (1H, dd, *J*=3.0, 6.5 Hz, H-2'), 3.75 (1H, m, H-3'), 3.30 (2H, m, H-5'), 3.42 (1H, m, H-4'), 3.37 (3H, br s, OMe), 3.34 (3H, br s, OMe); ^{13}C NMR (DMSO-d_6): δ 99.02 (C-1), 79.01 (C-2), 78.35 (C-3), 72.20 (C-4), 70.99 (C-5), 93.53 (C-1′), 78.68 (C-2′), 72.55 (C-3′), 71.73 (C-4′), 70.12 (C-5′), 55.61 (OMe), 55.32 (OMe); ESI MS *m/z* (rel. int.): 310 $[M]^+$ ($C_{12}H_{22}O_9$) (2.9), 163 (11.3), 147 (4.1).

2.3.3. Isolation of a glyceride from the seeds of *Prosopis cineraria*

2.3.3.1. Glyceryl-1-oleioyl-2-myristioyl-3-*O*-hydroxy dihydrocinnamate (**9**)

Elution of the column with petroleum ether furnished a yellow semisolid mass of **9**, purified by preparative TLC using petroleum ether - chloroform (1:1), UV λ_{max} (MeOH): 212, 273 nm (log ε 2.4, 3.7); IR γ_{max} (KBr): 3350, 2925, 2865, 1727, 1605, 1509, 1459, 1377, 1272, 1246, 1181, 1029, 826, 726 cm^{-1}; ^1H NMR ($CDCl_3$): d 7.72 (1H, m, H-6′′′), 7.52 (1H, m, H-7′′′), 7.13 (1H, m, H-8′′′), 6.82 (1H, d, *J*=7.6 Hz, H-9′′′), 5.37 (1H, m, H-9′), 5.28 (1H, m, H-10′), 4.30 (1H, m, H-2), 4.19 (2H, d, *J*=6.0 Hz, H_2-1), 4.13 (2H, m, H_2-3), 2.28 (2H, t, *J*=7.2 Hz, H_2-2′), 2.19 (2H, t, *J*=7.5 Hz, H_2-2′′), 2.05 (2H, t, *J*=7.2 Hz, H_2-2′′′), 2.01

(2H, m, H_2-3′′′), 1.68 (4H, m, 2 x CH_2), 1.59 (4H, m, 2 x CH_2), 1.48 (2H, m, CH_2′), 1.25 (38H, brs, 19 x CH_2), 0.86 (3H, t, *J*=6.6 Hz, Me-18′), 0.83 (3H, t, *J*=6.3 Hz, Me-14′′); ESI MS *m/z* (rel. int.): 714 $[M]^+$ ($C_{44}H_{74}O_7$) (1.3), 265 (2.6), 211 (12.9), 165 (3.7).

2.3.3.2. 2,3,4-Trihydroxybenzyl *n*-hexadecanyl ether (**10**)

Elution of the column with chloroform afforded a pale yellow semisolid mass of **10**, purified by preparative TLC using chloroform, UV λ_{max} (MeOH): 213, 276 nm (log ε 2.3, 3.4); IR γ_{max} (KBr): 3378, 3265, 2921, 2854, 1576, 1457, 1374, 1091, 722 cm^{-1}; ^1H NMR ($CDCl_3$): d 7.09 (1H, d, *J*=7.8 Hz, H-5), 6.82 (1H, d, *J*=7.8 Hz, H-6), 4.15 (1H, brs, H_2-7a), 4.05 (1H, brs, H_2-7b), 3.61 (2H, t, *J*=8.0 Hz, H_2-1′), 2.12 (2H, m, CH_2), 1.87 (2H, m, CH_2), 1.67 (2H, m, CH_2), 1.49 (2H, m, CH_2), 1.25 (20H, brs, 10 x CH_2), 0.83 (3H, t, *J*=6.5 Hz, Me-16′); ESI MS *m/z* (rel. int.): 380 $[M]^+$ ($C_{23}H_{40}O_4$) (2.7), 225 (7.3), 155 (2.6).

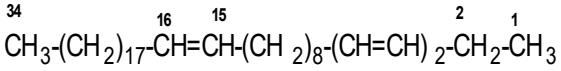
2.3.3.3. Salicyloyl O-α-D-glucosyl-2′-oleate (**11**)

Elution of the column with chloroform-methanol (19:1) gave a pale yellow crystals of **11**, recrystallized from chloroform-methanol (1:1), 218 mg, UV λ_{max} (MeOH): 209, 284 nm (log ε 2.1, 3.2); IR γ_{max} (KBr): 3403, 3365, 2923, 2851, 1727, 1635, 1575, 1407, 1276, 1174, 1087, 894 cm^{-1}; ^1H NMR ($CDCl_3$): d 7.69 (1H, m H-3), 7.59 (1H, m, H-4), 7.09 (1H, m, H-5), 6.80 (1H, d, *J*=8.4 Hz, H-6), 5.31 (1H, m, H-9′′), 5.29 (1H, m, H-10′′), 5.23 (1H, d, *J*=5.6 Hz, H-1′), 4.17 (1H, dd, *J*=5.6, 5.7 Hz, H-2′), 4.03 (1H, m, H-5′), 3.81 (1H, m, H-3′), 3.70 (1H, m, H-4′), 3.30 (2H, d, *J*=9.2 Hz, H2-6′), 2.29 (2H, t, *J*=7.6 Hz, H_2-2′′), 2.18 (2H, m, H_2-8′′), 2.01 (2H, m, H_2-11′′), 1.68 (2H, m, CH_2), 1.55 (2H, m, CH_2), 1.27 (18H, brs, 9 x CH_2), 0.84 (3H, t, *J*=6.7 Hz, Me-18′′); ESI MS *m/z* (rel. int.): 548 $[M]^+$ ($C_{31}H_{48}O_8$) (1.6), 265 (7.4), 121 (100).

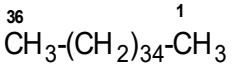
3. Results and Discussion

3.1. Spectroscopic characteristics of compound **1**

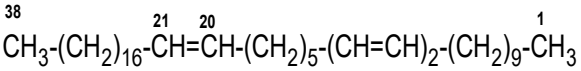
Compound **1** showed IR absorption bands for unsaturation (1637 cm^{-1}) and long aliphatic chain (723 cm^{-1}). Its mass spectrum displayed a molecular ion peak at *m/z* 472 consistent with the molecular formula of an alkene, $C_{34}H_{64}$. The generation of the ion peaks at *m/z* 443 [C_2-C_3 fission, $CH_3(CH_2)_{17}CH{=}CH\text{-}(CH_2)_8(CH{=}CH)_2]^+$, 391 [$C_6$-$C_7$ fission, $CH_3(CH_2)_{17}CH{=}CH\text{-}(CH_2)_8]^+$, 279 [$C_{14}$-$C_{15}$ fission, $CH_3(CH_2)_{17}CH{=}CH]^+$ and 253 [C_{16}-C_{17} fission, $CH_3(CH_2)^{17}]^+$ indicated the presence of the vinylic linkages at C-7, C-5 and C-15 positions in the alktriene chain. The ^1H NMR spectrum of **1** exhibited six multiplets integrating each for one proton in the deshielded region at δ 5.26, 5.17, 5.14, 5.11, 5.08 and 5.05 with half-widths between 9.1-7.6 Hz assigned correspondingly to cis-oriented vinylic H-4, H-5, H-6, H-15, H-3 and H-16 protons. Two triplets integrating each for three protons at δ 0.91 (*J*=6.2 Hz) and 0.87 (*J*=6.1 Hz) were due to C-1 and C-34 primary methyl protons, respectively. The remaining methylene protons appeared between δ 2.13 - 1.29. The ^{13}C NMR spectrum of **1** showed signals for vinylic carbons from δ 134.96 to 124.26, methylene carbons between δ 39.75 - 22.72 and methyl carbons at δ 16.07 (C-1) and 14.12 (C-34). The absence of any signal from δ 5.05 to 2.13 in the ^1H NMR spectrum and between δ 124.26 - 39.75 in the ^{13}C NMR spectrum ruled out the existence of any carbinol proton in the molecule. The ^1H-^1H COSY spectrum of **1** showed correlations of H-3 with H_3-1, H_2-2, H-3, H-4 and H-5; and H-15 with H_2-14, H-16 and H_2-17. On the basis of the foregoing account, the structure of **1** was formulated as (*Z,Z,Z*)-*n*-tetratriacont-3,5,15-triene, a new alktriene (Fig. 1). Compound **2** was a known aliphatic constituent identified as *n*-hexatriacontane (Seki et al., 1977; Yassa et al., 2009).



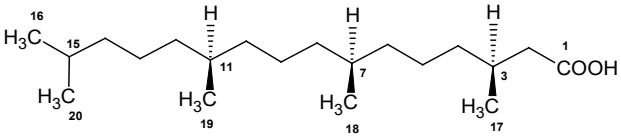
n-Tetratriacont-3,5,15- triene (**1**)



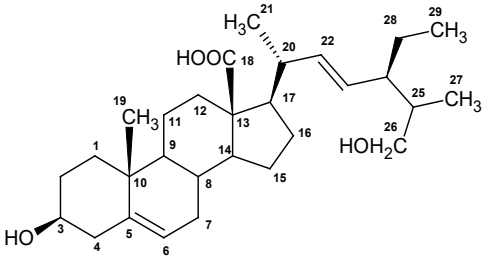
n-Hexatriacontane (**2**)



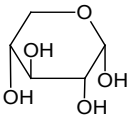
n-Octatriacont-11,13,20-triene (**3**)



Phytanic acid (**4**)



26-Hydroxystigmaster-18-oic acid (**5**)



α-L-xylose (**6**)

Fig. 1. Chemical constituents **1-6** isolated from the leaves of *Fraxinus excelsior*.

3.2. Spectroscopic characteristics of compound **3**

Compound **3**, $[M]^+$ at *m/z* 528 ($C_{38}H_{72}$), showed IR absorption bands for unsaturation (1638 cm^{-1}) and long aliphatic chain (721 cm^{-1}). The production of the ion peaks at *m/z* 387 [C_{10}-C_{11} fission, $CH_3(CH_2)_{16}CH{=}CH\text{-}(CH_2)_5(CH{=}CH)_2]^+$, 335 [$C_{14}$-$C_{15}$ fission, $CH_3(CH_2)_{16}CH{=}CH\text{-}(CH_2)_5]^+$, 265 [$C_{19}$-$C_{20}$ fission, $CH_3(CH_2)_{16}CH{=}CH]^+$ and 239 [C_{21}-C_{22} fission, $CH_3\text{-}(CH_2)_{16}]^+$ indicated the presence of the vinylic linkages at C-11, C-13 and C-20 positions in the alktriene chain. The ^1H NMR spectrum of **3** displayed six multiplets integrating each for one proton in the deshielded region between δ 5.86-4.99 with half-widths from 9.2 to 6.6 Hz assigned to cis-oriented vinylic H-12, H-13, H-14, H-11, H-20 and H-21 protons. Two triplets integrating each for three protons at δ 0.86 (*J*=6.4 Hz) and 0.82 (*J*=6.5 Hz) were due to C-1 and C-38 primary methyl protons, respectively. The remaining methylene protons resonated in the range of δ 2.05 - 1.25. The ^{13}C NMR spectrum of **3** showed signals for vinylic carbons from δ 139.29 to 114.08, methylene carbons between δ 39.76 - 22.72 and methyl carbons at δ 16.04 (C-1) and 14.15 (C-38). The absence of any signal from δ 4.99 to 2.05 in the ^1H NMR spectrum and between δ 114.08-39.76 in the ^{13}C NMR spectrum ruled out the existence of any carbinol proton in the molecule. The ^1H-^1H COSY spectrum of **3** showed correlations of H-12 with H-11, H_2-10, H-13, H-14 and H_2-15; and H-20 with H_2-19, H-21 and H_2-22. On the basis of the foregoing account, the structure of **3** was formulated as (*Z,Z,Z*)-*n*-octatriacont-11,13,20-triene, a new alktriene (Fig. 1). Compound **4** was a known diterpenic constituent characterized as phytanic acid (3,7,11,15-tetramethylhexadecanoic acid) (Ellinghaus et al., 1999; van den Brink and Wanders, 2006).

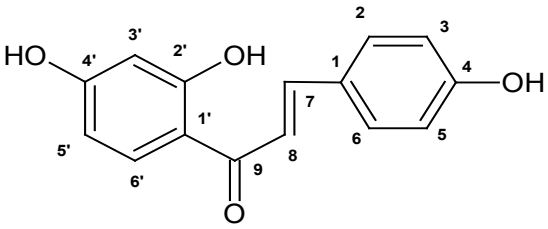
3.3. Spectroscopic characteristics of compound **5**

Compound **5** produced effervescence with sodium bicarbonate solution due to the presence of a carboxylic group and had IR distinctive absorption bands for hydroxyl functions (3420, 3365 cm^{-1}), carboxylic group (3280, 1693 cm^{-1}) and unsaturation (1636 cm^{-1}). Its molecular ion peak was established at *m/z* 458 on the basis of mass and ^{13}C NMR spectra corresponding to the molecular formula of a sterol $C_{29}H_{46}O_4$. The ion peaks arising at *m/z* 440 [M-H_2O, $C_{29}H_{44}O_3]^+$ and 413 [M-COOH, $C_{28}H_{45}O_2]^+$ supported the presence of one each of carbinol and carboxylic functions in the molecule. The expulsion of a side chain with mass unit of 155 produced an ion peak at *m/z* 303 [M-$C_{10}H_{19}O$, side chain]$^+$ indicating the existence of the saturated C_{10} side chain with a hydroxyl group. The ^1H NMR spectrum of **5** exhibited three multiplets integrating each for one proton at δ 5.25, 5.05 and 5.01 assigned correspondingly to vinylic H-6, H-22 and H-23 protons of a stigmasterol-type molecule, a one-proton broad multiplet at δ 3.81 with half-width of 18.5 Hz ascribed to α-oriented carbinol H-3 proton, a two-proton doublet at δ 3.22 (*J*=7.2 Hz) accounted to hydroxymethylene H_2-26 protons, a three-proton singlet at δ 1.08 due to tertiary C-19 methyl protons, two doublets integrating each for three protons at δ 0.92 (*J*=6.1 Hz) and 0.87 (*J*=6.0 Hz) attributed to secondary C-21 and C-27 methyl protons and a three-proton triplet at δ 0.77 (*J*=6.5 Hz) associated with primary C-29 methyl protons. The remaining methylene and methine protons resonated from δ 2.17 to 1.12. The ^{13}C NMR spectrum of **5** displayed 29 carbon signals including carboxylic carbon at δ 181.22 (C-18), vinylic carbons at δ 140.07 (C-5), 120.18 (C-6), 138.21 (C-22) and 129.32 (C-23), carbinol carbon at δ 73.25 (C-3), hydroxymethylene carbon at δ 63.43 (C-26) and methyl carbons at δ 19.13 (C-19), 18.49 (C-21), 19.36 (C-27) and 11.84 (C-29). The ^1H and ^{13}C NMR spectral data of the steroidal nucleus were compared with the reported spectral values of similar compounds (Akhtar et al., 2010; Mustafa and Ali, 2011; Jung et al., 2012). The DEPT spectrum of 5 displayed the presence of four methyl, ten methylene, eleven methine and four quaternary carbons. The ^1H-^1H COSY spectrum of **5** exhibited correlations of H-3 with H_2-1, H_2-2 and H_2-4; H-6 with H_2-4, H_2-7 and H-8; H-22 with H-17, H-20, H_3-21, H-23 and H-24; and H-25 with H-24, H_2-26 and H_3-27. Its HMBC spectrum showed that H-3, H_2-4, H-6 and H_2-7 interacted with C-5; H-14, H_2-12 and H-17 interacted with C-18; and H-23, H-24, H_2-26 and H_3-27 interacted with C-25. On the basis these evidences the structure of **5** has been elucidated as 26-hydroxystigmasterol-18-oic acid, a new steroidal acid (Fig. 1). Compound **6** (Fig. 1) was a known monosaccharide identified as α-L-xylose (Usvalampi et al., 2012; Sultana et al., 2018).

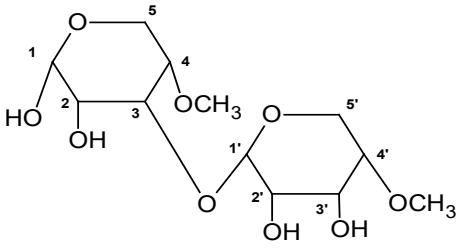
Compound **7** was a chalcone derivative characterized as isoliquiritigenin (Ma et al., 2005; Sato et al., 2007).

3.4. Spectroscopic characteristics of compound **8**

Compound **8**, named di-4-methoxy-α-L-xyloside, $[M]^+$ at *m/z* 310 ($C_{12}H_{22}O_9$), gave positive tests for glycosides and showed IR absorption bands for hydroxyl groups (3403, 3318, 3265 cm^{-1}). The ion fragments generated at *m/z* 163 [O-$C_{1'}$ fission, $C_6H_{11}O_5]^+$ and 147 [M-163, $C_6H_{11}O_4]^+$ indicated that two methoxypentose units were linked in the molecule. The ^1H NMR spectrum of **8** exhibited two doublets integrating each for one proton at δ 4.65 (*J*=2.8 Hz) and 4.55 (*J*=3.0 Hz) assigned to anomeric H-1 and H-1′ protons, respectively, supported the existence of α-glycosidic units of the disaccharide. The other sugar protons resonated between δ 4.46 - 3.34. Two singlets integrating each for three protons at δ 3.37 and 3.34 were associated with the methoxy protons. The ^{13}C NMR spectrum of **8** displayed signals for anomeric carbons at δ 99.02 (C-1) and 93.53 (C-1′), other sugar carbons from δ 79.01 to 70.12 and methoxy carbons δ 55.61 and 55.32. The presence of the sugar H-3 signal in the deshielded region as a one-proton multiplet at



Isoliquiritigenin (**7**)



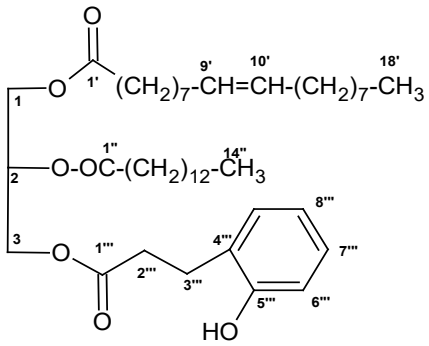
Di-4 methoxy-α-L-xyloside (**8**)

Fig. 2. Chemical constituents **7** and **8** isolated from the leaves of *Senna sulfurea*.

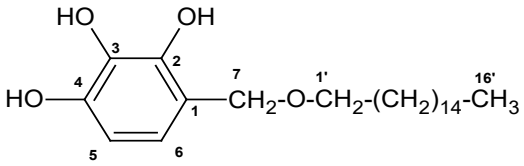
δ 4.28 in the ^{1}H NMR spectrum and C-3 carbon signal at δ 78.35 in the ^{13}C NMR spectrum suggested (3→1′) linkage of the sugar units. The ^{1}H-^{1}H COSY spectrum of **8** exhibited correlations of H-3 with H-1, H-2, H-4, H_2-5, OMe and H-1′; and H-3′ with H-1′, H-2′, H-4′, OMe and H_2-5′. Its HMBC spectrum showed that H-1, H-2, H-4, H_2-5 and H-1′ interacted with C-3; and H-1′, H-2′, H-4′, OMe and H_2-5′ interacted with C-3′. On the basis of these evidences the structure of **8** has been formulated as 4-methoxy-α-L-xylopyranosyl-(3→1′)-O-α-L-4′-methoxyxylopyranoside, a new dixyloside (Fig. 2).

3.5. Spectroscopic characteristics of compound **9**

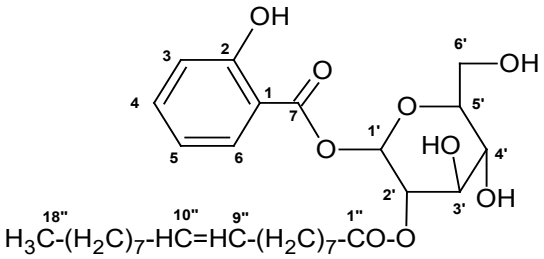
Compound **9** had UV absorption maximum at 273 nm for aromatic compounds, showed IR absorption bands for a hydroxyl group (3350 cm^{-1}), ester function (1727 cm^{-1}), aromaticity (1605, 1509, 1029 cm^{-1}) and long aliphatic chain (726 cm^{-1}) and gave positive tests for phenols. Its mass spectrum showed a molecular ion peak at *m/z* 714 consistent with the molecular formula of a lipid glyceride, $C_{44}H_{74}O_7$. The ion peaks arising at *m/z* 265 [$C_{1'}$-O fission, $CH_3(CH_2)_7$-CH=CH-$(CH_2)_7CO]^+$, 211 [$C_{1''}$-O fission, $CH_3(CH_2)_{12}$-$CO]^+$ and 165 [$C_6H_4(OH)$-CH_2-CH_2-$COO]^+$ indicated that oleic acid, myristic acid and o-hydroxydihydrocinnamic acid were linked with glycerol unit. The ^{1}H NMR spectra of **9** exhibited three multiplets integrating each for one proton at δ 7.72, 7.52 and 7.13 and a one - proton doublet at δ 6.82 (*J*=7.6 Hz) assigned to aromatic H-6‴ to H-9‴ protons, two multiplets integrating each for one proton at δ 5.37 and 5.28 accounted correspondingly to vinylic protons H-9′ and H-10′ protons, a one - proton multiplet at δ 4.30 due to oxymethine H-2, oxymethylene protons as a two-proton doublet at δ 4.19 (*J*=6.0 Hz, H_2-1) and a



Glycerol-1-oleiyl-2-myristioyl-3-O-hydroxydihydrocinnamate (**9**)



2,3,4-Trihydroxybenzyl *n*-hexadecanyl ether (**10**)



Salicyloyl O-α-D- glucosyl-2'-oleate (**11**)

Fig. 3. Structures of the chemical constituents **9-11** isolated from the leaves of *Prosopis cineraria*.

two-proton multiplet at δ 4.13 (H_2-3), other methylene protons from δ 2.28 to 1.25 and two triplets integrating each for three protons at δ 0.86 (*J*=6.6 Hz) and 0.83 (*J*=6.3 Hz, Me-14‴) ascribed to primary C-18′ and C-14‴ methyl protons, respectively. The HMBC spectrum of **9** displayed interactions of H_2-1 and H_2-3 with C-2; H_2-8′, H-9′ and H_2-11′ with C-10′; H-2‴ and H-3‴ with C-1‴; and H-6‴ and H-7‴ with C-5‴. On the basis of these evidences, the structure of **9** has been characterized as glyceryl-1-oleioyl-2-myristioyl-3-o-hydroxydihydrocinnamate, a new lipid component (Fig. 3).

3.6. Spectroscopic characteristics of compound **10**

Compound **10**, $[M]^+$ at *m/z* 380 ($C_{23}H_{40}O_4$), responded positive tests for phenols, showed UV absorption maximum at 276 nm for aromatic compounds and had IR absorption bands for hydroxyl groups (3378, 3265 cm^{-1}), aromaticity (1576, 1091 cm^{-1}) and long aliphatic chain (722 cm^{-1}). The ion peaks arising at *m/z* 155 [C_7-O fission, $C_6H_2(OH)_3$-$CH_2O]^+$ and 225 [M-

155, $CH_2(CH_2)_{14}CH_3]^+$ indicated that *n*-hexadecane was linked with trihydroxybenzyl alcohol. The ^{1}H NMR spectra of **10** exhibited two doublets integrating each for one proton at δ 7.09 (*J*=7.8 Hz, H-5) and 6.82 (*J*=7.8 Hz, H-6) assigned to aromatic *ortho*-coupled H-5 and H-6 protons, respectively, two singlets integrating each for one proton at δ 4.15 and 4.05 accounted to oxymethylene H_2-7 protons attached to the aromatic ring, a two-proton triplet at δ 3.61 (*J*=8.0 Hz) due to oxymethylene H_2-1′, other methylene protons from δ 2.12 to 1.25 and a three-proton triplet at δ 0.83 (*J*=6.5 Hz) ascribed to primary C-16′ methyl protons. The ^{1}H-^{1}H COSY spectrum of **10** showed correlations of H-5, H-6, H_2-1′ with H_2-7. The HMBC spectrum of **10** displayed interactions of H-5, H-6 and H_2-7 with C-1; and H_2-7 and H_2-1′ with C-2′. On the basis of these evidences, the structure of **10** has been characterized as 2,3,4-trihydroxybenzyl *n*-hexadecanyl ether, a new phenolic ether (Fig. 3).

3.7. Spectroscopic characteristics of compound **11**

Compound **11**, named salicyloyl O-α-L-glucosyl-2′-oleate, gave positive tests for phenols and glycosides and had UV absorption maximum at 284 nm for aromaticity. Its IR spectrum showed absorption bands for hydroxyl groups (3403, 3365 cm^{-1}), ester function (1727 cm^{-1}), unsaturation (1620 cm^{-1}) and aromatic ring (1575, 1087 cm^{-1}). Its mass spectrum exhibited a molecular ion peak at *m/z* 548 consisting of a molecular formula of an aromatic carboxylic glucosidic ester, $C_{31}H_{48}O_8$. An ion peak arising at *m/z* 121 [C_7-O fission, $HO\text{-}C_6H_4\text{-}CO]^+$ indicated that salicyloyl unit was linked with a glycosidic moiety. The ion peak generated at *m/z* 265 $[CH_3(CH_2)_7CH{=}CH\text{-}(CH_2)_7CO]^+$ indicated that oleic acid was esterified with the glycosidic unit. The ^{1}H NMR spectrum of **11** showed three multiplets integrating each for one proton at δ 7.69, 7.59 and 7.09 and a one-proton doublet at δ 6.80 (*J*=8.4 Hz) assigned to aromatic H-3, H-4, H-5 and H-6 protons, respectively. Two multiplets integrating each for one proton at δ 5.31 and 5.29 were ascribed correspondingly to vinylic H-9′′ and H-10′′ protons. A one-proton doublet at δ 5.23 (*J*=5.6 Hz) was accounted to α-oriented anomeric H-1′ proton. The other sugar protons appeared as a one-proton double doublet at δ 4.17 (*J*=5.6, 5.7 Hz , H-2′), as one-proton multiplets at δ 4.03 (H-5′), 3.81 (H-3′) and 3.70 (H-4′) and as a two-proton doublet at δ 3.30 (*J*=9.2 Hz, H2-6′). The presence of the sugar H-2′ proton in the deshielded region at δ 4.17 indicated attachment of the ester linkage at C-2′. The methylene protons of the fatty acid chains resonated in the range of δ 2.29 - 1.27. A three-proton triplet at δ 0.84 (*J*=6.7 Hz, Me-18′′) was associated with the terminal C-18′′ primary methyl protons. The ^{1}H-^{1}H COSY spectrum of **11** showed correlations of H-3, H-5 and H-6 with H-4; H-2′, H-3′ and H-5′ with H-1′; and H_2-8′′, H-9′′ and H_2-11′′ with H-10. The HMBC spectrum of **11** exhibited that H-3 and H-4 interacted with C-2; H-6 and H-1′ interacted with C-7; H-2′ and H-2′′ interacted with C-1′′; H2-8′′, H-9′′ and H_2-11′′ interacted with C-10′′. Acid hydrolysis of **11** yielded salicylic acid, m. p. 157-158 ºC; R_f 0.70 (benzene-acetic acid-diethylether-methanol, 60:9:30:5); α-D-glucose acid, R_f 0.78 (*n*-butonal- acetic acid-water , 4:1:1.6) and oleic acid (R_f 0.34, 85% glacial acetic acid). The absolute configuration of α-D-glucose was determined by measuring its specific rotation, [α]D 25º+112º (water). On the basis of the foregoing account, the structure of **11** has been established as salicyloyl O-α-D-glucopyranosyl-2′-oleate, a new phenolic acid glucosidic ester (Fig. 3).

4. Concluding remarks

Phytochemical investigation of the leaves of *Fraxinus excelsior* afforded three aliphatic constituents viz., (*Z,Z,Z*)-*n*-tetratriacont-3,5,15-triene (**1**), *n*-hexatriacontane (**2**) and (*Z,Z,Z*)-*n*-octatriacont-11,13,20-triene (**3**), phytanic acid (**4**), 26-hydroxystigmasterol-18-oic acid (**5**) and α-L-xylose (**6**). The leaves of *Senna sulfurea* furnished isoliquiritigenin (**7**) and di-4-methoxy-α-L-xyloside (**8**). The leaves of *Prosopis cineraria* yielded glyceryl-1-oleioyl-2-myristioyl-3-*O*-hydroxydihydrocinnamate (**9**), 2,3,4-trihydroxybenzyl *n*-hexadecanyl ether (**10**) and salicyloyl *O*-α-D-glucopyranosyl-2′-oleate (**11**). This work has enhanced understanding about the phytoconstituents of the plant. These compounds may be used as chromatographic markers for standardization of the tubers of the plant.

Conflict of interest

The authors declare that there is no conflict of interest.

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References

Akhtar, N., Ali, M., Alam, M.S., 2010. New steroidal glycosides from the stem bark of *Mimusops elengi*. Chem. Nat. Compd. 46(4), 549-553.

Anonymous, 2003. The Wealth of India-Raw Materials. NISCOM (CSIR), New Delhi, Vol. 4, p. 399.

Anonymous, 2012. Assessment report on *Fraxinus excelsior* L. or *Fraxinus angustifolia* Vahl, folium. European Medicine Agency. EMA/HMPC/239269/2011, London, United Kingdom. 1-16.

Bai, N., He, K., Ibarra, A., Bily, A., Roller, M., Chen, X., Ruhl, R., 2010. Iridoids from *Fraxinus excelsior* with adipocyte differentiation-inhibitory and PPARα activation activity. J. Nat.

Prod. 73(1), 2-6.

Bruneton, J., 1999. Coumarins. In: Bruneton J. Pharmacognosy, Phytochemistry, Medicincal Plants. 2nd Edition. Lavoisier Publishing Inc., Paris. pp. 263-267.

Carnat, A., Lamaison, J.L., Duband, F., 1990. Teneurs en principaux constituants de la feuille de frêne, *Fraxinus excelsior* L. Plantes Méd Phytotér. 24, 145-151.

Damtoft, S., Franzyk, H., Jensen, S.R., 1992. Excelsioside, a secoiridoid glucoside from *Fraxinus excelsior*. Phytochemistry 31, 4197-4201.

Duke, J.A., Bogenschutz-Godwin, M.J., du Cellier, J., Duke, P.A.K., 2002. European ash (*Fraxinus excelsior* L.) In: Duke JA, Bogenschutz-Godwin MJ, duCellier J, Duke PAK. Handbook of Medicinal Herbs. CRC Press, Boca Ranton, London, New York, Washington D.C., p. 280.

Egan, P., Middleton, P., Shoeb, M., Byres, M., Kumarasamy, Y., Middleton, M., 2004. Gl 5, a dimer of oleoside, from *Fraxinus excelsior* (Oleaceae). Biochem. Syst. Ecol. 32, 1069-1071.

Ellinghaus, P., Wolfrum, C., Assmann, G., Spener, F., Seedorf, U., 1999. Phytanic acid activates the peroxisome proliferator-activated receptor α (PPARα) in sterol carrier protein 2-/sterol carrier protein x-deficient mice. J. Biol. Chem. 274(5), 2766-2772.

El-Sayed, M.M., Abdel- Aziz, M.M., Abdel-Gawad, M.M., Abdel-Hameed, E.S.S., Ahmed, W.S., Abdel-Lateef , E.E., 2013. Chemical constituents and cytotoxic activity of *Cassia glauca* Lam. leaves. Life Sci. J. 10(3), 1617-1625.

Gaedcke, F., 1993. Fraxinus. In: Hänsel, R., Keller, K., Rimpler, H., Schneider, G., 1993. editors. Hagers Handbuch der Pharmazeutischen Praxis. Drogen E-O, Springer-Verlag, Berlin, 5, 188-200.

Gangal, S., Sharma, S., Rauf, A., 2009. Fatty acid composition of *Prosopis cineraria* seeds. Chem. Nat. Comp. 45(5), 705-707.

Garg, A., Mittal, S.K., 2013. Review on *Prosopis cineraria*: A potential herb of Thar desert. Drug Invent. Today 5, 60-65.

Ghazanfar, S.A., Alsabahi, A.M.A., 1993. Medicinal plants of northern and central Oman (Arabia). Econ Bot. 47(1), 89-98.

Gruenwald, J., Brendler, T., Jaenicke, C., 2007. Ash, *Faxinus excelsior*. In: Gruenwald, J., Brendler, T., Jaenicke, C., Editors. PDR for herbal medicines. Thomson, pp. 53-54.

Hemlata, Kalidhar, S.B., 1994. Chemical composition of *Cassia glauca* Lam. Indian J. Pharmaceut. Sci. 56(1), 33-34.

Iossifova, T., Kostova, I., Evstatieva, L., 1997. Secoiridoids and hydroxycoumrains in Bulgarian *Fraxinus* species. Biochem. Syst. Ecol. 25, 271-274.

Janbaz, K.H., Haider, S., Imran, I., Zia-Ul-Haq, M., Martino, L.D., Feo, V.D., 2012. Pharmacological Evaluation of *Prosopis cineraria* (L.) Druce in gastrointestinal, respiratory, and vascular disorders. Evidence-Based Complem. Altern. Med. doi:10.1155/2012/735653.

Jung, W.S., Chung, I.M., Ali, M., Ahmad, A., 2012. New steroidal glycoside ester and aliphatic acid from the fruits of *Lycium chinensis*. J. Asian Nat. Prod. Res. 14(4), 301-307.

Kerr, G., 1998. A review of black heart of ash (*Fraxinus excelsior* L). Forestry 71(1), 49-56.

Khan, S.T., Riaz, N., Afza, N., Nelofar, A., Malik, A., Ahmed, E., Hussain, S., 2006. Studies on the chemical constituents of *Prosopis cineraria*. J. Chem. Soc. Pakistan 28(6), 619-622.

Kirtikar, K.R., Basu, B.D., Eds. 1984. Indian Medicinal Plants. Vol. III, Bishen Singh and Mahendra Pal Singh, Dehradun, Allahabad, pp. 1664-1666.

Kittur, B.S., Srinivas, Y., Deshpande, S.R., 2015. Evaluation of leaf and stem extracts from *Cassia glauca* L. for antimicrobial activity. Int. J. Pure Appl. Zool. 3(1), 98-102.

Kostova, I., Iossifova, T., 2007. Chemical components of *Fraxinus* species. Fitoterapia 78, 85-106.

Kiritikar, K.R., Basu, B.D., 1990. Indian Medicinal Plants, Periodical experts, New Delhi, pp. 910-911; p. 2333.

Kumar, D., Arora, S., Verma, A., 2013. Fatty acid composition and antimicrobial and antioxidant activity of *Cassia glauca* seed extracts. Int. J. Phytopharmacol. 4(2), 113-118.

Liu, Y., Singh, D., Nair, M.G., 2012. Pods of Khejri (*Prosopis cineraria*) consumed as a vegetable showed functional food properties. J. Funct. Foods. 4(1), 116-121.

Ma, C.-J., Li, G.-S., Zhang, D.-L., Liu, K., Fan, X., 2005. One step isolation and purification of liquiritigenin and isoliquiritigenin from *Glycyrrhiza uralensis* Risch. using high-speed counter-current chromatography. J. Chromatogr. A. 1078, 188-192.

Malik, A., Kalidhar, S., 2007. Phytochemical examination of *Prosopis cineraria* L. (Druce) leaves. Indian J. Pharmaceut. Sci. 69(4), 576-578.

Mustafa, A., Ali, M., 2011. New steroidal lactones and homomonoterpenic glucoside from fruits of *Malva sylvestris* L. Acta Poloniac Pharmac. Drug Res. 68(3), 393-401.

Nadkarni, K.M., 2000. Indian Materia Medica, Vol. 1, Popular Prakashan, Mumbai, India, 290, 1011-1014.

Oddo, E., Saiano, F., Alonzo, G., Bellini, E., 2002. An investigation of the seasonal pattern of mannitol content, in deciduous and evergreen species of the Oleaceae grooving in northern Sicily. Ann. Bot. 90, 239-243.

Quattrocchi, U., 2012. CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology. CRC Press, Boca Raton, Florida, 3417.

Rai, K.N., Kaushalendra, K., Singh, J., 1997. Chemical constituents from the pods of *Cassia glauca* Lam. Asian J. Chem. 9(3), 558-560.

Sanz, M., de Simón, B.F., Cadahía, E., Esteruelas, E., Muñoz, A.M., Hernández , T., Estrella, I., Pinto, E., 2012. LC-DAD/ESI-MS/MS study of phenolic compounds in ash (*Fraxinus excelsior* L. and *F. americana* L.) heartwood. Effect of toasting intensity at cooperage. Mass Spectrom. 47(7), 905-918.

Sato, Y., He, J.X., Nagai, H., Tani, T., Akao, T., 2007. Isoliquiritigenin, one of the antispasmodic principles of *Glycyrrhiza ularensis* roots, acts in the lower part of intestine. Biol Pharm. Bull. 30(1), 145-149.

Seki, K., Hashimoto, S., Sato, N., Harada, Y., Ishii, K., Inokuchi, H., Kanbe, J.I., 1977. Vacuum-ultraviolet photoelectron spectroscopy of hexatriacontane ($nC_{36}H_{74}$) polycrystal: A model compound of polyethylene. J. Chem. Physics. 66, 3644.

Sharma, S., Soni, P.L., 1994. Structural investigation of *Prosopis cineraria* (Kherzi) seed galacto-mannan. Indian J. Chem. 33B, 355-361.

Sultana, S., Ali, M., Mir, S.R., 2018. Chemical constituents from the aerial parts of *Jasminum auriculatum* Vahl and seeds of *Holarrhena pubescens* Wall. ex G. Don. Acta Scientific Pharma. Sci. 2(3), 16-21.

Tahirović, A., Bašić, N., 2016. Determination of phenolic

content and antioxidant capacity of *Fraxinus excelsior* L. and *Fraxinus angustifolia* Vahl. leaves and bark extracts. Rad. Šumar. fak. Univ. Sarajevu 46(1), 29-41.

Usvalampi, A., Turunen, O., Valjakka, J., Pastinen, O., Leisola, M., Nyyssölä, A., 2012. Production of L-xylose from L-xylulose using *Escherichia coli* L-fucose isomerase. Enzyme Microb. Tech. 50, 71-76.

Warrier, P.K., Nambiar, V.P.K., Ramankutty, C., 1996. Indian Medicinal Plants: A Compendium of 500 species. Orient Longman Pvt. Ltd., Hyderabad, p. 423.

van den Brink, D.M., Wanders, R.J.A., 2006. Phytanic acid: production from phytol, its breakdown and role in human disease. Cellular Mole. Life Sci. 63(15), 1752-1765.

Yassa, N., Masoomi, F., Rankouhi, S.E.R., Hadjiakhoondi,