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Phenolic Compounds Isolated from *Opuntia ficus-indica* Fruits

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Abstract – On the phytochemical investigation of a 70% ethanol extract of the fruits of *Opuntia ficus-indica*, (Cacataceae), we could result in the isolation of thirteen phenolic compounds including seven flavonoids (**1 - 9**) and four simple phenolic glycosides (**10 - 13**) by column chromatographic methods. Among the isolated compounds, picein (**11**), androsin (**12**), and 1-*O*-feruloyl-*β*-D-glucopyranoside (**13**) were isolated for the first time from *O. ficus-indica*; additionally, this is the first report benzyl-*O*-*β*-D-glucopyranoside (**10**) from the genus *Opuntia*. The structures of the compounds were determined by spectral data analysis which included 1D, 2D NMR spectrum and ESIMS.

Keywords – *Opuntia ficus-indica,* Cacataceae, Phenolic, Flavonoid, Chemotaxonomy

Introduction

Opuntia, belonging to the Cactaceae family, is a perennial species commonly called the "prickly pear," "tuna," or "nopal." As a folk medicine in Mexico, the pulp and juice of the *Opuntia* species are used to treat wounds and inflammation of the digestive and urinary tracts.[1] Among the *Opuntia* species, *Opuntia ficus-indica* (L.) Mill. (Cactaceae) is one of the most important plants because it is widely distributed and cultivated around the world. It has been reported that *O. ficus-indica* has various biological activities such as anti-allergic, anti-inflammatory, antimicrobial, antioxidant, antiulcer, hepatoprotective, hypoglycemic, neuroprotective, and wound healing effects.[2-9] Previous studies on the chemical constituents of *O. ficus-indica* revealed the presence of alkaloids, flavonoids, terpenoids, polysaccharides, and organic acids.[10-12] Among the constituents, phenolic compounds such as flavonoids are known as the most characteristic constituent of the cactus pear.[13] Therefore, this study performed a phytochemical investigation of phenolic compounds from the fruits of *O. ficus-indica* by various chromatographic methods.

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Experimental

General experimental procedures – Optical rotations were measured on a Jasco DIP-1000 polarimeter in MeOH. NMR spectra, including HMQC and HMBC experiments, were recorded on a Bruker GPX 400 NMR spectrometer and Bruker AMX 500 spectrometer with chemical shifts given in ppm (δ). Preparative HPLC was conducted using a Gilson 321 pump with Gilson UV/Vis-151 detector and Kromasil 100-10-C-18 column (250 × 20 mm i.d.). Silica gel 60 (Kiesgel 60, 40 - 63 μmm, 230 - 400 mesh, Art. 9385, Merck), ODS gel (YMC-GEL ODS-A, AA12SA5), and Sephadex LH-20 (Pharmacia Co.) were used for open column chromatography.

Plant materials – The fruits of *O. ficus-indica* used in this work were provided from DAEWON Pharm. Co., Ltd. which collected from Jeju province of South Korea in June 2011. A voucher specimen (SNUPH-11201) was deposited at the medicinal herb garden of Seoul National University, Goyang, Gyeonggi, South Korea.

Extraction and isolation – The dried and powdered fruits of *O. ficus-indica* (13.0 kg) were extracted with 70% EtOH (12 L, 90 min × 5) in an ultrasonic apparatus. After removal of the solvent in vaccuo, the 70% EtOH extract (2.2 kg) was suspended in H2O and successively partitioned into n-hexane fraction (28.0 g), CHCl3 fraction (7.9 g), and n-BuOH fraction (219.0 g), respectively.

The n-BuOH fraction was subjected to a HP-20 column eluting with water containing increasing amounts of methanol (0, 50, and 100%) to obtain 3 fractions. B-2

fraction (5.0 g) was subjected to silica gel column chromatography (CC) (45 cm × 10 cm) eluted with mixtures of CHCl3-MeOH-Water (from 50:4:1 to 6:5:1, v/v/v) to yield 10 fractions (B-2-1~B-2-10). B-2-4 (0.7 g) subjected to MPLC (Reveleris C18, 40 g, MeOH-Water, from 0:100 to 88:12, 20 mL/min) to yield thirteen fractions (B-2-4-1~B-2-4-13). Compound **10** (31.3 mg) and **12** (10.9 mg) were isolated from B-2-4-3 (80.0 mg) by c.c. on Sephadex LH-20 using MeOH. B-2-5 (4.0 g) was further separated into two fractions (B-2-5-1~B-2-5-2) using MPLC (C18, 120 g, MeOH-Water, from 0:100 to 83:17, 50 mL/min). Compound **11** (6.8 mg) and **13** (3.7 mg) were obtained from B-2-5-1 through preparative HPLC (YMC Pack C18, 150 × 20 mm, AcCN-Water, 15:85, 4 mL/min, UV 254 nm). B-3 fraction (29.3 g) was separated into five fractions (B-3-1~B-3-5) by CC on Sephadex LH-20 using MeOH. Compound **3** (3.9 mg) was isolated from B-3-3 (0.4 g) by preparative HPLC (YMC Pack C18, 150 × 20 mm, AcCN-Water, 58:42, 4 mL/min, UV 254 nm). Compound **5** (13.9 mg) was obtained from B-3-4 (60 mg) through preparative HPLC (YMC Pack C18, 150 × 20 mm, AcCN-Water, 30:70, 4 mL/min, UV 254 nm). B-3-2 (3.7 g) was further separated into three fractions (B-3-2-1~B-3-2-3) using silica gel CC eluted with mixtures of CHCl3-MeOH-Water (from 17:4:1 to 0:1:0, v/v/v). Compound **2** (200.0 mg) was obtained from B-3-2-2 by recrystallization. B-3-2-3 (0.3 g) was further separated into four fractions (B-3-2-3-1~B-3-2-3-4) using preparative HPLC (C18, 500 × 20 mm, MeOH-Water, 50:50, 4 mL/min, UV 254 nm). Compound **2** (16.2 mg) and **9** (8.2 mg) isolated from B-3-2-3-1 through MPLC (Reveleris Silica, 40g, Chloroform-MeOH, from 90:10 to 0:100, 40 mL/min). Compound **4** (1.1 mg) and **6** (4.2 mg) obtained from B-3-2-3-3 by MPLC (Reveleris Silica, 40 g, Chloroform-MeOH, from 90:10 to 0:100, 40 mL/min). Compound **1** (26.3 mg), **7** (3.0 mg), and **8** (45.4 mg) obtained from B-3-2-3-4 by using MPLC (Reveleris Silica, 40 g, Chloroform-MeOH, from 90:10 to 0:100, 40 mL/min).

Aromadendrin (1) – pale yellowish amorphous powder; ESIMS: *m/z* 287 $[M–H]^–$; $[\alpha]_D^{25}$: +58.6 (*c* = 0.30, MeOH); ^{1}H-NMR (400 MHz, DMSO-d_6): δ 7.31 (2H, d, *J* = 8.5 Hz, H-2', 6'), 6.78 (2H, d, *J* = 8.5 Hz, H-3', 5'), 5.91 (1H, d, *J* = 2.0 Hz, H-8), 5.86 (1H, d, *J* = 2.0 Hz, H-6), 5.05 (1H, d, *J* = 11.4 Hz, H-2), 4.58 (1H, dd, *J* = 11.5, 4.8 Hz, H-3); ^{13}C-NMR (100 MHz, DMSO-d_6): δ 197.9 (C-4), 166.8 (C-7), 163.3 (C-5), 162.6 (C-9), 157.7 (C-4'), 129.5 (C-2', 6'), 127.6 (C-1'), 114.9 (C-3', 5'), 100.5 (C-10), 96.0 (C-6), 95.0 (C-8), 82.9 (C-2), 71.4 (C-3).

(+)-Taxifolin (2) – pale yellowish amorphous powder; ESIMS: *m/z* 303 $[M–H]^–$; $[\alpha]_D^{25}$: +40.1 (*c* = 0.30, MeOH); ^{1}H-NMR (400 MHz, DMSO-d_6): δ 7.31 (1H, d, *J* = 1.4 Hz, H-2'), 6.74 (2H, s, H-5'/6'), 5.90 (1H, d, *J* = 2.0 Hz, H-8), 5.85 (1H, d, *J* = 2.0 Hz, H-6), 4.97 (1H, d, *J* = 11.2 Hz, H-2), 4.50 (1H, dd, *J* = 11.2, 6.2 Hz, H-3); ^{13}C-NMR (75 MHz, DMSO-d_6): δ 197.7 (C-4), 166.8 (C-7), 163.3 (C-5), 162.6 (C-9), 145.8 (C-4'), 144.9 (C-3'), 128.1 (C-1'), 119.4 (C-6'), 115.4 (C-5'), 115.1 (C-2'), 100.5 (C-10), 96.0 (C-6), 95.0 (C-8), 83.1 (C-2), 71.6 (C-3).

Kaempferol (3) – yellowish amorphous powder; ESIMS: *m/z* 285 $[M–H]^–$; ^{1}H-NMR (400 MHz, DMSO-d_6): δ 8.03 (2H, dd, *J* = 11.6, 2.8 Hz, H-2', 6'), 6.93 (2H, dd, *J* = 9.8, 2.7 Hz, H-3', 5'), 6.43 (1H, d, *J* = 2.0 Hz, H-8), 6.18 (1H, d, *J* = 2.0 Hz, H-6); ^{13}C-NMR (75 MHz, DMSO-d_6): δ 175.8 (C-4), 163.9 (C-7), 160.7 (C-5), 159.1 (C-4'), 156.1 (C-9), 146.8 (C-2), 135.6 (C-3), 125.9 (C-2', 6'), 121.6 (C-1'), 115.4 (C-3', 5'), 103.0 (C-10), 98.2 (C-6), 93.5 (C-8).

Kaempferol 3-methyl ether (4) – yellowish amorphous powder; ESIMS: *m/z* 299 $[M–H]^–$; ^{1}H-NMR (500 MHz, DMSO-d_6): δ 7.93 (2H, d, *J* = 8.9 Hz, H-2', 6'), 6.94 (2H, d, *J* = 8.8 Hz, H-3', 5'), 6.43 (1H, d, *J* = 1.9 Hz, H-8), 6.19 (1H, d, *J* = 2.1 Hz, H-6), 3.77 (3H, s, O-CH_3); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 177.9 (C-4), 164.3 (C-7), 161.2 (C-5), 160.2 (C-4'), 156.4 (C-9), 155.6 (C-2), 137.6 (C-3), 130.1 (C-2', 6'), 120.6 (C-1'), 115.7 (C-3', 5'), 104.1 (C-10), 98.6 (C-6), 93.7 (C-8), 59.7 (O-CH_3).

Quercetin (5) – yellowish amorphous powder; ESIMS: *m/z* 301 $[M–H]^–$; ^{1}H-NMR (400 MHz, DMSO-d_6): δ 7.67 (1H, d, *J* = 2.1 Hz, H-2'), 7.53 (1H, dd, *J* = 8.4, 2.2 Hz, H-6'), 6.88 (1H, d, *J* = 8.5 Hz, H-5'), 6.40 (1H, d, *J* = 1.9 Hz, H-8), 6.18 (1H, d, *J* = 1.8 Hz, H-6); ^{13}C-NMR (75 MHz, DMSO-d_6): δ 175.8 (C-4), 163.9 (C-7), 160.7 (C-5), 156.1 (C-9), 147.7 (C-2), 146.7 (C-4'), 145.0 (C-3'), 135.7 (C-3), 121.9 (C-1'), 119.9 (C-6'), 115.6 (C-5'), 115.0 (C-2'), 103.0 (C-10), 98.2 (C-6), 93.3 (C-8).

Quercetin 3-methyl ether (6) – yellowish amorphous powder; ESIMS: *m/z* 315 $[M–H]^–$; ^{1}H-NMR (500 MHz, DMSO-d_6): δ 7.55 (1H, d, *J* = 2.2 Hz, H-2'), 7.44 (1H, dd, *J* = 8.5, 2.2 Hz, H-6'), 6.90 (1H, d, *J* = 8.5 Hz, H-5'), 6.40 (1H, d, *J* = 1.9 Hz, H-8), 6.18 (1H, d, *J* = 1.8 Hz, H-6), 3.78 (3H, s, O-CH_3); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 177.9 (C-4), 164.1 (C-7), 161.3 (C-5), 156.3 (C-9), 155.6 (C-2), 148.7 (C-4'), 145.3 (C-3'), 137.7 (C-3), 120.8 (C-1'), 120.6 (C-6'), 115.8 (C-5'), 115.4 (C-2'), 104.2 (C-10), 98.6 (C-6), 93.6 (C-8), 59.7 (O-CH_3).

Isorhamnetin (7) – yellowish amorphous powder; ESIMS: *m/z* 315 $[M–H]^–$, 361 $[M+HCOOH-H]^–$; ^{1}H-NMR (500 MHz, DMSO-d_6): δ 7.75 (1H, d, *J* = 2.2 Hz, H-2'), 7.69 (1H, dd, *J* = 8.5, 2.0 Hz, H-6'), 6.94 (1H, d, *J* = 8.4 Hz, H-5'), 6.47 (1H, d, *J* = 1.9 Hz, H-8), 6.19 (1H, d, *J* = 1.9 Hz, H-6), 3.84 (3H, s, O-CH_3); ^{13}C-NMR (125

MHz, DMSO-d_6): δ 175.9 (C-4), 163.9 (C-7), 160.7 (C-5), 158.8 (C-2), 156.1 (C-9), 147.3 (C-3'), 146.6 (C-4'), 135.8 (C-3), 122.0 (C-1'), 121.7 (C-6'), 115.5 (C-5'), 111.7 (C-2'), 103.0 (C-10), 98.2 (C-6), 93.6 (C-8), 55.8 (O-CH_3).

Isorhamnetin 3-*O*-*β*-D-glucopyranoside (8) – pale yellowish amorphous powder; ESIMS: *m/z* 315 $[M\text{-}Glc]^-$, 477 $[M–H]^-$; ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.02 (1H, d, *J* = 1.9 Hz, H-2'), 7.51 (1H, dd, *J* = 8.4, 2.0 Hz, H-6'), 6.90 (1H, d, *J* = 8.6 Hz, H-5'), 6.44 (1H, d, *J* = 1.9 Hz, H-8), 6.21 (1H, d, *J* = 1.9 Hz, H-6), 5.50 (1H, d, *J* = 7.7 Hz, H-1"), 3.85 (3H, s, O-CH_3), 3.68 (1H, m, C-4"), 3.56 (1H, m, C-2"), 3.50 (1H, m, C-6"a), 3.40 (1H, m, C-5"), 3.37 (1H, m, C-3"), 3.36 (1H, m, C-6"b); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 177.4 (C-4), 164.1 (C-7), 161.2 (C-5), 156.3 (C-9), 156.2 (C-2), 149.4 (C-4'), 146.9 (C-3'), 133.1 (C-3), 121.8 (C-6'), 121.0 (C-1'), 115.1 (C-5'), 113.5 (C-2'), 104.0 (C-10), 101.6 (C-1"), 98.2 (C-6), 93.6 (C-8), 75.9 (C-3"), 73.1 (C-5"), 71.2 (C-2"), 67.9 (C-4"), 60.3 (C-6"), 55.9 (O-CH_3).

Narcissin (9) – pale yellowish amorphous powder; ESIMS: *m/z* 315 $[M\text{-}Rha\text{-}Glc]^-$, 623 $[M–H]^-$, 668 $[M+HCOOH\text{-}H]^-$; ^{1}H-NMR (500 MHz, CD_3OD): δ 7.94 (1H, d, *J* = 2.0 Hz, H-2'), 7.62 (1H, dd, *J* = 8.5, 2.0 Hz, H-6'), 6.91 (1H, d, *J* = 8.6 Hz, H-5'), 6.41 (1H, d, *J* = 2.0 Hz, H-8), 6.21 (1H, d, *J* = 2.0 Hz, H-6), 5.24 (1H, d, *J* = 7.4 Hz, H-1"), 4.52 (1H, d, *J* = 1.1 Hz, H-1'"), 3.94 (3H, s, O-CH_3), 3.81 (1H, m, C-6"a), 3.60 (1H, m, C-3'"), 3.48 (1H, m, C-2'"), 3.47 (1H, m, C-2"), 3.45 (1H, m, C-3"), 3.41 (1H, m, C-6"b), 3.41 (1H, m, C-5'"), 3.36 (1H, m, C-5"), 3.25 (1H, m, C-4'"), 3.24 (1H, m, C-4"), 1.09 (1H, d, *J* = 6.2 Hz, C-6'"); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 180.2 (C-4), 166.8 (C-7), 163.8 (C-5), 159.7 (C-2), 159.3 (C-9), 151.7 (C-4'), 149.1 (C-3'), 136.3 (C-3), 124.8 (C-6'), 123.8 (C-1'), 116.9 (C-5'), 115.4 (C-2'), 106.1 (C-10), 105.2 (C-1"), 103.3 (C-1'"), 100.8 (C-6), 95.7 (C-8), 79.0 (C-3"), 78.2 (C-5"), 76.7 (C-2"), 74.6 (C-4'"), 73.1 (C-2'"), 72.9 (C-3'"), 72.4 (C-4"), 70.6 (C-5'"), 69.3 (C-6"), 57.6 (O-CH_3), 18.7 (C-6'").

Benzyl-*O*-*β*-D-glucopyranoside (10) – white amorphous powder; ESIMS: *m/z* 269 $[M–H]^-$; ^{1}H-NMR (500 MHz, CD_3OD): δ 7.39 (2H, d, *J* = 7.2 Hz, H-2, 6), 7.34 (2H, d, *J* = 7.3 Hz, H-3, 5), 7.28 (1H, d, *J* = 7.3 Hz, H-4), 4.83 (1H, d, *J* = 12.2 Hz, H-7a), 4.58 (1H, d, *J* = 12.2 Hz, H-7b), 4.23 (1H, d, *J* = 7.8 Hz, H-1'), 3.04-3.77 (m, H-Glc); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 138.1 (C-1), 128.1 (C-3, 5), 127.6 (C-2, 6), 127.4 (C-4), 102.1 (C-1'), 77.0 (C-3'), 76.5 (C-5'), 73.5 (C-2'), 70.1 (C-4'), 69.5 (C-7), 61.2 (C-6').

Picein (11) – white amorphous powder; ESIMS: *m/z* 297 $[M–H]^-$; ^{1}H-NMR (400 MHz, CD_3OD): δ 7.92 (2H, d, *J* = 8.9 Hz, H-2, 6), 7.11 (2H, d, *J* = 8.8 Hz, H-3, 5), 5.00 (1H, d, *J* = 7.3 Hz, H-1'), 3.17-3.77 (m, H-Glc), 2.52 (3H, s, H-8); ^{13}C-NMR (100 MHz, DMSO-d_6): δ 196.4 (C-7), 161.0 (C-4), 130.8 (C-1), 130.2 (C-2, 6), 115.8 (C-3, 5), 99.7 (C-1'), 77.1 (C-3'), 76.5 (C-5'), 73.1 (C-2'), 69.6 (C-4'), 60.6 (C-6'), 26.4 (C-8).

Androsin (12) – white amorphous powder; ESIMS: *m/z* 327 $[M–H]^-$; ^{1}H-NMR (500 MHz, CD_3OD): δ 7.58 (1H, dd, *J* = 8.4, 1.8 Hz, H-6), 7.46 (1H, d, *J* = 1.8 Hz, H-2), 7.17 (1H, d, *J* = 8.5 Hz, H-5), 5.05 (1H, d, *J* = 7.1 Hz, H-1'), 3.17-3.77 (m, H-Glc), 3.82 (3H, s, O-CH_3), 2.53 (3H, s, H-8); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 196.5 (C-7), 150.6 (C-3), 148.7 (C-4), 130.8 (C-1), 122.7 (C-6), 114.1 (C-5), 110.9 (C-2), 99.4 (C-1'), 77.1 (C-3'), 76.8 (C-5'), 73.1 (C-2'), 69.5 (C-4'), 60.5 (C-6'), 55.6 (OCH_3), 26.4 (C-8).

1-*O*-feruloyl-*β*-D-glucopyranoside (13) – pale yellowish amorphous powder; ESIMS: *m/z* 355 $[M–H]^-$, 401 $[M+HCOOH\text{-}H]^-$; ^{1}H-NMR (500 MHz, DMSO-d_6): δ 7.63 (1H, d, *J* = 15.9 Hz, H-3), 7.15 (1H, dd, *J* = 8.2, 1.5 Hz, H-6'), 7.34 (1H, d, *J* = 1.6 Hz, H-2'), 6.80 (1H, d, *J* = 8.2 Hz, H-5'), 6.48 (1H, d, *J* = 16.0 Hz, H-2), 5.46 (1H, d, *J* = 8.1 Hz, H-1"), 3.82 (3H, s, O-CH_3), 3.66 (1H, m, C-6"a), 3.46 (1H, m, C-6"b), 3.23 (1H, m, C-3"), 3.22 (1H, m, C-5"), 3.20 (1H, m, C-2"), 3.07 (1H, m, C-4"); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 165.4 (C-1), 149.6 (C-4'), 147.9 (C-3'), 146.3 (C-3), 125.5 (C-1'), 123.3 (C-6'), 115.5 (C-5'), 113.9 (C-2), 111.4 (C-2'), 94.2 (C-1"), 77.8 (C-5"), 76.5 (C-3"), 72.5 (C-2"), 69.5 (C-4"), 60.6 (C-6"), 55.7 (O-CH_3).

Result and Discussion

The phytochemical investigation of a 70% ethanol extract of *O. ficus-indica* fruits led to the isolation of thirteen phenolic compounds: nine flavonoids (**1 - 9**) and four simple phenolic glycosides (**10 - 13**) (Fig. 1).

The structures of the isolated compounds were determined by spectroscopic methods including 1D, 2D NMR, and ESIMS. By comparing the spectroscopic data with the reported literature values, the compounds were identified as (+)-aromadendrin (**1**), (+)-taxifolin (**2**), kaempferol (**3**), kaempferol 3-methyl ether (**4**), quercetin (**5**), quercetin 3-methyl ether (**6**), isorhamnetin (**7**), isorhamnetin 3-*O*-*β*-D-glucopyranoside (**8**), narcissin (**9**), benzyl-*O*-*β*-D-glucopyranoside (**10**), picein (**11**), androsin (**12**), and 1-*O*-feruloyl-*β*-D-glucopyranoside (**13**), respectively.[10,14-23]

Compound **10** was isolated as white amorphous powder and its molecular formula was deduced as $C_{13}H_{18}O_6$ by ESIMS (*m/z* 269 $[M–H]^-$) together with the ^{13}C NMR

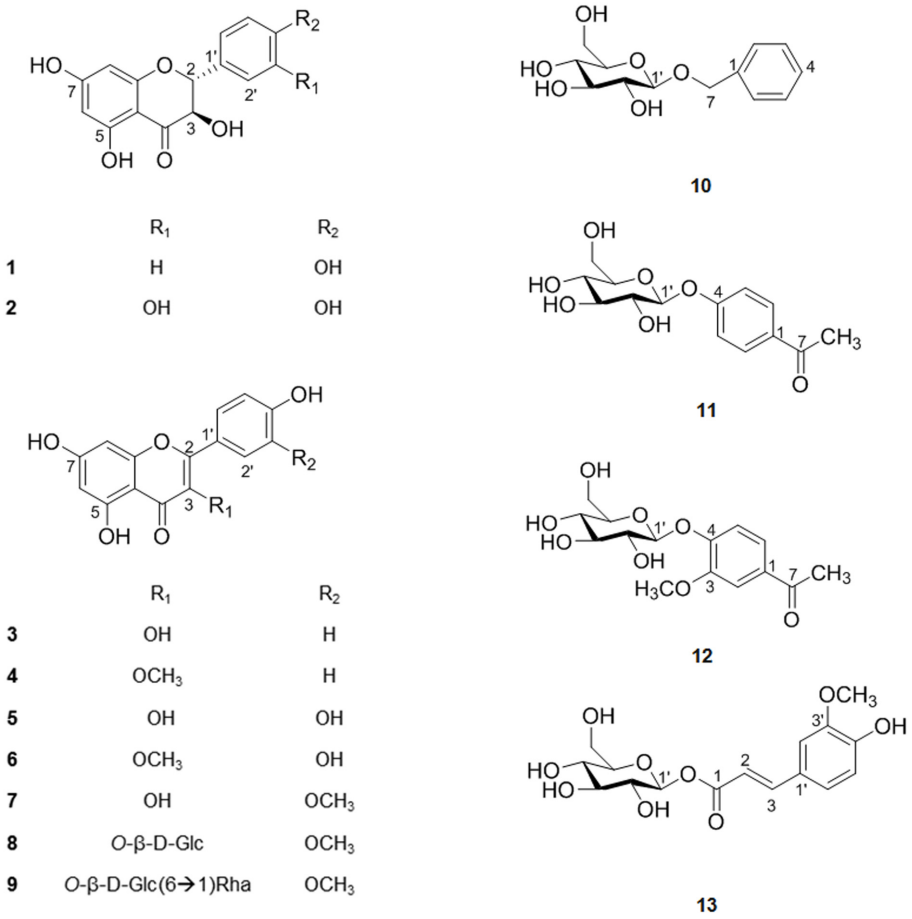

Fig. 1. The structures of compounds **1 - 13** isolated from *O. ficus-indica*.

data. The ^{1}H and ^{13}C NMR spectral data displayed the characterized signals of phenolic glycosides including a benzyl group and glucose protons. Compound **11** was obtained as white amorphous powder and its molecular formula was $C_{14}H_{18}O_7$ based on ESIMS (*m/z* 297 $[M-H]^-$). The ^{1}H NMR spectrum exhibited the characterized signals of phenolic glycosides including aromatic protons [δ_H 7.92 (2H, d, J = 8.9 Hz, H-2, 6), 7.11 (2H, d, J = 8.8 Hz, H-3, 5)], an acetyl proton [2.52 (3H, s, H-8)], and glucose protons. The ^{1}H NMR and ^{13}C NMR spectra of compound **12** were similar to those of compound **11** except for the signals of an aromatic ring [δ_H 7.58 (1H, dd, J = 8.4, 1.8 Hz, H-6), 7.46 (1H, d, J = 1.8 Hz, H-2), 7.17 (1H, d, J = 8.5 Hz, H-5)] and a methoxy group [δ_H 3.82 (3H, s, OCH_3), δ_c 55.6 (OCH_3)]. Compound **13** was isolated as white amorphous powder and its molecular formula was deduced as $C_{16}H_{20}O_9$ by ESIMS (*m/z* 355 $[M-H]^-$, 401 $[M+HCOOH-H]^-$). The ^{1}H NMR spectrum revealed the presence of an aromatic ring [δ_H 7.15 (1H, dd, J = 8.2, 1.5 Hz, H-6'), 7.34 (1H, d, J = 1.6 Hz, H-2'), 6.80 (1H, d, J = 8.2 Hz, H-5')], an olefinic group [δ_H 7.63 (1H, d, J = 15.9 Hz, H-3), 6.48 (1H, d, J = 16.0 Hz, H-2), an methoxy group [δ_H 3.82 (3H, s, OCH_3)], and a glucose. From the analysis of HMBC spectrum, the correlation peaks from δ_H 7.63 (1H, d, J = 15.9 Hz, H-3) to δc 165.4 (C-1), 123.3 (C-6') and 111.4 (C-2'), from δ_H 6.48 (1H, d, J = 16.0 Hz, H-2) to δc 165.4 (C-1) and 125.5 (C-1'), from δ_H 5.46 (1H, d, J = 8.1 Hz, H-1") to δc 165.4 (C-1) and from δ_H 3.82 (1H, s, OCH3) to δc 147.9 (C-3') indicated the presence of feruloyl moiety and location of sugar moiety. The sugar moiety was suggested as *β*-D-glucose from the coupling constant of aromatic proton (J = 8.1) and chemical shift of aromatic carbon (δc 94.2).

There have been reports that flavonoids are the main chemical constituents of a cactus *O. ficus-indica*. Among the reported flavonoids, the isorhamnetin moiety flavonoids such as isorhamnetin 3-*O*-*β*-D-glucopyranoside and narcissin were known to be the most abundant in this plant.[24,25] Through the isolation of compounds **1 - 9**, we were able to confirm that our results are in agreement with those found in other literature on the chemical composition of *O. ficus-indica*.

Moreover, compound **10** was isolated from the *Opuntia* species for the first time. Benzyl-*O*-*β*-D-glucopyranoside (**10**) was previously reported from the Cactaceae family only in *Epiphyllum oxypetalum*.[26] Additionally, compounds **11** and **12** were isolated for the first time from this plant. Compound **13** was analyzed in *O. ficus-indica* previously, but this was its first isolation as a single compound.[27]

In conclusion, the present study showed that chemical compounds from *O. ficus-indica* closely match the ones observed in other species of the genus *Opuntia*. This is in agreement with the phytochemical data which confirm that *O. ficus-indica* belongs to the *Opuntia* species and to the family of Cacataceae. These chemotaxonomic findings could be helpful in understanding the phytochemical characteristic of *O. ficus-indica* fruits and their biological application in the development of natural superfoods or pharmaceutical medicines.

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