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RESEARCH ARTICLE

Quaternary alkaloids of *Argemone mexicana*

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Abstract
Four quaternary isoquinoline alkaloids, dehydrocorydalmine, jatrorrhizine, columbamine, and oxyberberine, have been isolated from the whole plant of *Argemone mexicana* Linn. (Papaveraceae) and their structures established by spectral evidence. This is the first report of these alkaloids (dehydrocorydalmine, jatrorrhizine, columbamine, and oxyberberine) from *Argemone mexicana* and the *Argemone* genus.

Keywords: Argemone mexicana*; quaternary isoquinoline alkaloids; dehydrocorydalmine; jatrorrhizine; columbamine; oxyberberine*

Introduction

Argemone mexicana L. (Papaveraceae) is an erect, prickly annual herb with bright yellow flowers, up to 1.2 m in height. This plant is naturalized throughout India up to an altitude of 1500 m, and is also distributed in Nepal, Bangladesh, Fiji Island, Mauritius, Mexico, and America. It is a very common weed in both agricultural and non-cultivated land, and grows during the summer season. The plant prefers light sandy soil and can grow in nutritionally poor soil. It is commonly known as Mexican Poppy (Anonymous, 1985; Das & Khanna, 1997). The plant is bitter, diuretic, and purgative; it is reported to destroy worms, cures itching, and is used in the treatment of leprosy, various skin diseases, inflammations, bilious fevers, diarrhea, and dysentery (Anonymous, 1985). The seeds are highly toxic due to the presence of the alkaloids sanguinarine and dihydrosanguinarine. Consumption of edible oils contaminated with *A. mexicana* seed oil causes various toxic manifestations leading to epidemic dropsy, which poses a serious threat to human health (Das & Khanna, 1997).

A review of the literature revealed the presence of a number of protopine, berberine, benzo-phenanthridine, and benzylisoquinoline type alkaloids (Slavikova & Slavik, 1955; Mishra et al., 1961; Haisova & Slavik, 1975; Doepke et al., 1976; Hussain et al., 1983; Nakkady & Shamma, 1988; Chang et al., 2003a, 2003b). In view of our interest in alkaloid constituents, we report here the isolation of four quaternary isoquinoline alkaloids from the whole plant of *A. mexicana*, not previously reported from this plant or the *Argemone* genus.

Materials and methods

Plant material

The whole plant of *Argemone mexicana* was collected in the month of May, 2007, from Varanasi district, India. The plant was identified by Professor N. K. Dubey, Department of Botany, Banaras Hindu University, Varanasi, India. A voucher specimen, No. 221, has been deposited in the herbarium of the department.

Extraction and isolation

Melting points were taken on Toshniwal apparatus and are uncorrected. Ultraviolet (UV) spectra were recorded on a PerkinElmer Carry-14 spectrophotometer and infrared (IR) spectra on a PerkinElmer 221 spectrophotometer. ^{1}H nuclear magnetic resonance (NMR) and ^{13}C NMR spectra were recorded on a Bruker spectrophotometer using tetramethylsilane as internal reference. Mass spectra (MS) were recorded using a Kratos MS 50 spectrophotometer operating at 70 eV, with evaporation

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of the sample in the ion source at about 200°C. BDH (India) grade solvents and chemicals were used throughout the experiment. Column chromatography was carried out over SiO_2 gel (60–120 mesh; BDH, India). Thin layer chromatography (TLC) plates were prepared with SiO_2 G (Centron Research Laboratories, India), and spots on TLC plates were visualized by spraying with Dragendorff's reagent.

The whole plant was collected, dried in sunlight, and powdered. The powdered plant material (3 kg) was extracted with MeOH (15 L) in a Soxhlet extractor. The extract was evaporated to dryness on a water bath, which furnished a brown, gummy mass (320 g). The MeOH extract was stirred with aqueous citric acid (7%) using a mechanical stirrer for 10 h. The acidic solution obtained after filtration was basified with NH_4OH (pH ~9) and exhaustively extracted with $CHCl_3$ (1.5 L) in a separating funnel. The aqueous alkaline solution left after $CHCl_3$ extraction was acidified with dilute HCl and treated with Mayer's reagent ($HgCl_2$ + KI) until complete precipitation of alkaloids. The precipitate was filtered and washed with water until free from excess reagent. The precipitate was suspended in ion-free water and stirred with IRA 410 (Cl^-) resin repeatedly until all the alkaloid constituents came into aqueous solution (Pandey et al., 1976). The aqueous solution was separated from the resin and concentrated under reduced pressure to a light brown, gummy mass (3.75 g). It was chromatographed over a SiO_2 gel column and eluted with a mixture of $CHCl_3$ and MeOH in 100 mL flasks. Each eluent was monitored by thin layer chromatography for its homogeneity. The eluates from $CHCl_3$–MeOH (50:1, 30:1, 20:1, and 8:1) were evaporated to dryness and crystallized from MeOH, which furnished, respectively, alkaloid **1** as light yellow granules (23 mg), m.p. 250–252°C; alkaloid **2** as yellow granules (17 mg), m.p. 205–206°C; alkaloid **3** as yellow shiny granules (21 mg), m.p. 209–211°C; and alkaloid **4** as golden yellow needles (24 mg), m.p. 198–200°C.

Dehydrocorydalmine (1)
$C_{20}H_{20}NO_4$, UV (MeOH) λ_{max} (log ε) nm: 226 (4.4), 265 (4.3), 350 (4.2), 430 (3.5); IR (KBr) ν_{max}, cm^{-1}: 3400 (OH); high resolution electron impact mass spectrometry (HREIMS), *m/z* (relative intensity, %): 338.1405 (M^+, 48) [calcd: 338.1392], 323 (25), 322 (10), 294 (28).

Jatrorrhizine (2)
$C_{20}H_{20}NO_4$, UV (MeOH) λ_{max} (log ε) nm: 229 (4.6), 266 (4.4), 349 (3.75), 429 (3.75); IR (KBr) ν_{max}, cm^{-1}: 3350 (OH); HREIMS, *m/z* (relative intensity, %): 338.1400 (M^+, 35) [calcd: 338.1392], 323 (35), 308 (20), 280 (16).

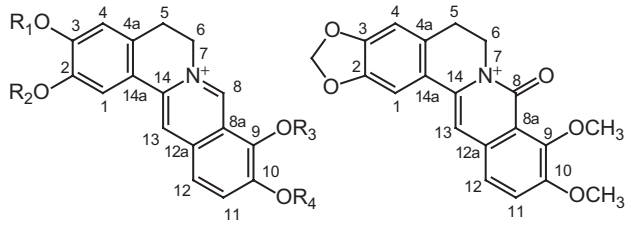
Columbamine (3)
$C_{20}H_{20}NO_4$, UV (MeOH) λ_{max} (log ε) nm: 230 (4.5), 266 (4.6), 355 (4.0), 432 (3.55); IR (KBr) ν_{max}, cm^{-1}: 3345 (OH); HREIMS, *m/z* (relative intensity, %): 338.1410 (M^+, 42) [calcd: 338.1392], 323 (35), 308 (20), 280 (16).

Oxyberberine (4)
$C_{20}H_{17}NO_5$, UV (MeOH) λ_{max} (log ε) nm: 222 (4.5), 290 (4.1), 340 (4.4); IR (KBr) ν_{max}, cm^{-1}: 1630, 1610, 1570, 1540; HREIMS, *m/z* (relative intensity, %): 351.110 (M^+, 38) [calcd: 351.1106], 337 (15), 322 (25), 294 (28).

Results and discussion

Chromatographic resolution of the quaternary alkaloid fraction of the MeOH extract of the whole plant of *A. mexicana* resulted in the isolation of alkaloids **1–4** (Figure 1). The ^1H NMR, and ^{13}C NMR, data (Tables 1 and 2) in comparison with the reported data fully supported the structure of compounds **1**, **2**, **3**, and **4**, respectively, as dehydrocorydalmine (Doskotch et al., 1967), jatrorrhizine (Wa et al., 1967), columbamine (Shamma & Rothenberg, 1978), and oxyberberine (Chatterjee & Maiti, 1955). The structures of **1–3** were further proved by borohydride reduction. The sodium borohydride reduction of alkaloids **1**, **2**, and **3** gave, respectively, the corresponding tetrahydro-derivatives as corydalmine (Bhakuni & Gupta, 1982), $C_{20}H_{23}NO_4$ (HRMS, *m/z* 341.1633 $[M]^+$), m.p. 170–172°C; corypalmine (Preininger et al., 1978), $C_{20}H_{23}NO_4$ (HRMS, *m/z* 341.1630 $[M]^+$), m.p. 225–227°C; and isocorypalmine (Preininger et al., 1978), $C_{20}H_{23}NO_4$ (HRMS, *m/z* 341.1633 $[M]^+$), m.p. 338–340°C. The structure of compound **4** was proved by heating berberine with NaOH (Shamma, 1972), which furnished a compound identical to compound **4**. The structures of compounds **1–4** were also substantiated by ^1H-^1H correlation spectroscopy (COSY) NMR in which C-5 and C-11 protons coupled, respectively, with protons of C-6 and C-12.

Although these quaternary alkaloids have been reported previously from other plant families (Grycová



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1 $R_1 = R_2 = R_3 = CH_3$, $R_4 = H$
2 $R_1 = H$, $R_2 = R_3 = R_4 = CH_3$
3 $R_1 = R_3 = R_4 = CH_3$, $R_2 = H$

Figure 1. Structure of alkaloids **1–4** isolated from the whole plant of *Argemone mexicana*.

Table 1. 500 MHz ^{1}H NMR ($CDCl_3$ + 20% CD_3OD) spectroscopic data of alkaloids **1–4**.

	^{1}H NMR, δH (ppm) (multi, *J* in Hz)			
Position of hydrogen	**1**	**2**	**3**	**4**
1	6.85 (1H, *s*)	7.45 (1H, *s*)	7.65 (1H, *s*)	6.85 (1H, *s*)
4	7.45 (1H, *s*)	7.05 (1H, *s*)	7.15 (1H, *s*)	7.45 (1H, *s*)
5	3.28 (2H, *m*)	3.19 (2H, *m*)	3.40 (2H, *m*)	3.38 (2H, *t*, 6)
6	5.05 (2H, *m*)	4.94 (2H, *m*)	5.14 (2H, *m*)	5.15 (2H, *t*, 6)
8	9.95 (1H, *s*)	9.60 (1H, *s*)	9.90 (1H, *s*)	—
11	7.91 (1H, *m*)	7.97 (1H, *d*, 8.5)	8.17 (1H, *d*, 9)	7.92 (1H, *d*, 8.5)
12	7.91 (1H, *m*)	7.89 (1H, *d*, 8.5)	8.10 (1H, *d*, 9)	7.90 (1H, *d*, 8.5)
13	8.40 (1H, *s*)	8.45 (1H, *s*)	8.75 (1H, *s*)	8.40 (1H, *s*)
2-OMe	4.25 (3H, *s*)	4.22 (3H, *s*)	—	—
3-OMe	4.10 (3H, *s*)	—	4.43 (3H, *s*)	—
2,3-O-CH_2-O	—	—	—	6.10 (2H, *s*)
9-OMe	4.41 (3H, *s*)	4.07 (3H, *s*)	4.28 (3H, *s*)	4.18 (3H, *s*)
10-OMe	—	4.01 (3H, *s*)	4.22 (3H, *s*)	4.25 (3H, *s*)

Table 2. 125 MHz ^{13}C NMR ($CDCl_3$ + 20% CD_3OD) spectroscopic data of alkaloids **1–4**.

Position of	^{13}C NMR, δC (ppm)			
carbon	**1**	**2**	**3**	**4**
1	114.36	114.68	108.75	108.8
2	149.06	149.97	148.72	140.0
3	150.97	144.18	150.70	152.5
4	108.54	108.36	105.36	105.5
4a	128.53	128.32	130.44	124.5
5	26.29	26.54	27.52	27.1
6	56.22	56.27	56.15	55.9
8	144.53	144.33	145.59	159.0
8a	119.48	121.67	122.22	122.7
9	148.33	148.06	144.98	148.0
10	144.06	150.33	151.02	152.0
11	126.00	126.53	126.88	127.1
12	121.67	119.67	120.15	119.0
12a	133.32	133.75	133.66	133.5
13	123.67	123.00	123.14	123.5
14	138.75	138.63	138.26	137.7
14a	117.68	117.48	120.26	117.0
2-OMe	56.33	56.33	—	—
3-OMe	56.27	—	56.26	—
2,3-O-CH_2-O	—	—	—	102.0
9-OMe	61.84	61.99	62.44	62.0
10-OMe	—	56.84	57.15	56.8

et al., 2007), this is the first report of these alkaloids from *Argemone mexicana* and the *Argemone* genus.

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***Declaration of interest*:** The authors report no conflicts of interest.

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