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Review Article

PLANT PROFILE, PHYTOCHEMISTRY AND PHARMACOLOGY OF *ARGEMONE MEXICANA* LINN. A REVIEW

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ABSTRACT

Argemone Mexicana is extensively used as traditional medicine for the treatment of numerous diseases. Various parts of the plant were extensively used in Ayurveda, Siddha, Unani and Homeopathic medicines. It is reported to have antimicrobial activity, wound healing property, larvicidal and chemosterilant activity, nematicidal and allelopathic potential, antimalarial, antibacterial and antifungal, molluscicidal, anticancer, hepatoprotective, anti-HIV and neuropharmacological activity. Chemical investigations of this plant have revealed the presence of alkaloids, amino acids, phenolics and fatty acids. *A. mexicana* has shown promise as an effective bio-control agent. The present review includes the detailed exploration of traditional uses, phytochemical and pharmacological properties and actions of whole plant extract reported so far.

Keywords: Plant Profile, Phytochemistry, Pharmacology, Biological activity, *Argemone mexicana,* Toxicity, Safety Evaluation.

INTRODUCTION

Plants have been used in medicines since time immemorial. India has a rich heritage of using medicinal plants in traditional medicines, as in the Ayurveda, Siddha and Unani systems besides folklore practices. The earliest inscription of the medicinal uses of plants is found in the "Rigveda", which is one of the oldest repositories of human knowledge. Fairly comprehensive information on the curative properties of some herbs has been found recorded in "Charak Samhita" and "Sushruta Samhita". The plant kingdom is a virtual goldmine of biologically active compounds and it is estimated that only 10-15% of existing species of higher plants have been surveyed. Many plants have been successfully used in the treatment of various diseases. The ancient record is evidencing their use by Indian, Chinese, Egyptian, Greek, Roman and Syrian dates back to about 5000 years. In India, around 20,000 medicinal plant species have been recorded recently, but more than 500 traditional communities use about 800 plant species for curing different diseases [1]. Currently, 80% of the world population depends on plant-derived medicine for the first line of primary health care for human alleviation**.**

A. mexicana, known as Mexican poppy or Mexican prickly poppy, is a species of poppy found in Mexico and now in the United States, India and Ethiopia. The plant is pantropic in distribution and it is a weed in waste places. It is native to America and naturalized throughout India. It is poisonous, but has been used medicinally by parts of Mexico. It possesses the alkaloid sanguinarine reported to be responsible for epidemic dropsy [2, 3]. *A. mexicana* is reported to have antimicrobial activity [4], wound healing capacity in rat [5], larvicidal and chemosterilant activity [6], nematicidal and allelopathic potential [7]. In Mexico infusion of aerial part of the plant is used as hypoglycemic [8]. Chemical investigations of this plant have revealed the presence of alkaloids [9, 10], amino acids [11] phenolics [12] and fatty acids [13]. The aerial part of the plant contains Isoquinoline and Benzylisoquinoline alkaloids. Alkaloids like Berberine and Tetrahydroberberine, Protopine, Benzophenanthridines has been isolated from the plant [14]. *A. mexicana* is used by traditional healers in Mali to treat malaria, externally in the treatment of cataracts and internally in the treatment of dropsy and jaundice [15]. *A. mexicana* has been investigated in terms of modern pharmacology for its anti-malarial activity [6, 15, 16], molluscicidal and nematicidal activity [17, 18], anticancer activity, antimicrobial activity [19, 20, 21, 22], hepatoprotective activity [23], anti-HIV activity [24] and neuropharmacological activity [25]. The present attempt is to review and compile updated information on various aspects of *A. mexicana*, a plant used all over the world.

Habitat

A. mexicana is native of tropical America which has distributed in tropical and subtropical regions of the World. In India, it grows in the temperate region as a weed in waste lands, cultivating fields and road sides. The plant prefers light sandy well-drained soil and also grows in nutritionally poor acidic, neutral and basic (alkaline) soil [21].

Scientific Classification

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida Dicotyledons
Subclass: Magnoliidae
Order: Papaverales
Family: Papavaraceae
Genus: *Argemone*
Species: *A. mexicana*

Authenticated name of *Argemone mexicana* L. according to IPNI

Argemone mexicana Linnaeus, Species Plantarum 2 1753
Argemone mexicana Linnaeus, Sp. Pl. 1: 508. 1753

Synonyms of *Argemone mexicana* L. (Papaveraceae)

Argemone alba, Raf.
Argemone mexicana var. *lutea* Kuntze.
Argemone mexicana var. *mexicana*.
Argemone mexicana var. *ochroleuca* Britton.
Argemone mexicana var. *parviflora* Kuntze.
Argemone mucronata Dum.Cours.ex Steud.
Argemone sexvalvis Stokes.
Argemone spinosa Gaterau.
Argemone spinosa Moench.
Argemone versicolor Salisb.
Argemone vulgaris Spach.
Echtrus mexicanus (L.)Nieuwl.
Echtrus trivialis Lour.
Papaver mexicanum (L.)E.H.L.Krause.

Basionym

Argemone leiocarpa Greene 1898.

Botanical Description

The plant is an erect prickly annual herb of about 1 m high; leaves are usually 5 to 11 cm long, and more or less blotched with green and white, glaucous broad at the base, half-clasping the stem prominently sinuate-lobed, and spiny [26]. The flowers become 4 to 5 cm in diameter, and are terminal, yellow, and scentless. The capsule is spiny, obovate or elliptic-oblong, and about 3 cm in length. The seeds are spherical, shining, black and pitted. Plants annual, Stems often branching from base, 2.5-8 cm, unarmed or sparingly prickly. Leaf blades: surfaces unarmed or sparingly prickly on veins; proximal lobed 1/2 or more distance to midrib; distal more shallowly lobed, mostly clasping. Inflorescences: buds subglobose, body 10-15 × 9-13 mm, unarmed or sparingly prickly; sepal horns teeter, 5-10 mm, unarmed. Flowers 4-7 cm broad, subtended by 1-2 foliaceous bracts; petals bright yellow or rarely pale lemon yellow; stamens 30-50; filaments yellow; pistil 4-6-carpellate. Capsules oblong to broadly ellipsoid, 25-45×12-20 mm (including stigma and excluding prickles when present), unarmed or prickly, longest prickles 6-10 mm. Seeds 1.6-2 mm. 2n = 28. *A. mexicana* is probably native to southern Florida as well as the Caribbean islands and has been introduced along the coast of the United States from New England to Texas and more infrequently, inland. Although it has been reported from Mississippi, no specimens are known. It is widespread in temperate and tropical regions around the world by introduction.

Medicinal importance of *A. mexicana* leaf

Leaves along with black pepper are used to cure diabetes. Leaf decoction is used in the treatment of malarial fever and ulcers. Leaves and seeds are also reported to find application in maintaining normal blood circulation and cholesterol level in human body [27], these plant parts possess anti-venom property as well [28, 29]. Aqueous extract of leaves have been reported to possess anti-inflammatory activity. A decoction from the leaves is drunk to treat stomach aches and used in baths to treat muscular pain. The leaves are useful in cough, wounds, ulcer, warts, cold sores, cutaneous affections, skin diseases, itches etc. [30].

Medicinal importance of *A. mexicana* root

The root is used for the treatment of chronic skin diseases and alterative. Roots are anthelmintic and also used in skin diseases, leprosy and inflammations [22]. It is used as antibacterial, cytotoxicity; wound healing, antioxidant and antifungal agent [22, 31, 32, 33, 34, 35, 36, 37]. They are expectorant and can be used in the treatment of coughs and other chest complaints. The alkaloid fractions of the root are reported to possess anti-inflammatory activity and strong uterine stimulant effect. The roots are useful in guinea-worm infestation, purities and menorrhagia, all types of poisoning, constipation, flatulence, colic, malarial fever, and vesicular calculus [30]. A maceration of the root is used to treat vaginal discharge and hepato-biliary problems.

Medicinal importance of *A. mexicana* seed

The seed oil is purgative and used in the treatment of skin problems. In Mexico, the seeds have been used as an antidote to snake poisoning [19]. In India, the smoke of the seeds is used to relieve toothache. The fresh yellow, milky seed extract contains protein-dissolving substances effective in the treatment of diuretic, anti-inflammatory, malarial fever, leprosy, scorpion sting, warts, cold sores, wound healing, skin diseases, itches, jaundice and an antidote to various poisons [37, 38, 39]. The seeds are known to be demulcent, emetic expectorant and laxative. An infusion, in small quantities can be used as sedative for children, but caution is advised since the oil in the seed is strongly purgative, the seed can also be used as an antidote to snake poisoning. The seeds and seed oil are employed as a remedy for dysentery, ulcers, asthma and other intestinal affections [40, 41]. Seeds are used as purgative, laxative and digestive, while its latex is used against conjunctivitis [42]. Besides, its infusion finds application against hypertension in Brazil. Seed yields non edible toxic oil and causes lethal dropsy when used with mustard oil while cooking and show lots of toxic effect [43]. The seeds are useful in vitiated conditions of kapha, cough, asthma, pertussis, ulcers, wounds, odantalgia, dental caries, constipation, rheumatalgia, colic, flatulence and antidote to snake poisoning [30]. The alkaloids Berberine, Protopine, Protopine hydrochloride, Sanguinarine and Dihydrosanguinarine have been isolated from the seeds. Protopine is considered as narcotic and it reduces morphine-withdrawl effects significantly. Protopine and Sanguinarine showed molluscicidal properties against *Lymnaea acuminate* and *Bioniphalaria glabrata*. Berberine has improving effects on the circulation in small doses and also has hallucinogenic properties. Other pharmacological effects of Berberine include spasmolytic antibacterial and to some degree antifungal and antiprotozoal activities [28].

Medicinal importance of *A. mexicana* flowers

Flowers are found to be expectorant and have been used in the treatment of coughs [44]. Antioxidant evaluation of *A. mexicana* was carried out using 1, 1-diphenyl-2- picrylhydrazyl radical (DPPH) free radical scavenging assay and exhibited considerable antioxidant potential and showed good correlation with the total phenolic (23.5mg GAE/gdw) and flavonoidal content (34.5mg QE/gdw). The highest radical scavenging effect was observed in flowers of *A. mexicana* with IC50=23.75µg/ml. *A. mexicana* possess significant antioxidant activity. Owing to these results, the plant has the potential to be used as a medicine against the diseases caused by free radicals [45].

Medicinal importance of *A. mexicana* juice/latex

The latex of *A. mexicana* used to treat boils by topical application on the site of boils. Juice of plant is applied on scorpion sting. The latex is considered a good wound dressing and is also used against dermatitis. The fresh juice of the leaves and the latex both are reported to be used externally as a disinfectant for open wounds and cuts [39]. Juice of the plant is used as a remedy against Scorpion bite [39]. The latex is useful in dropsy, jaundice, skin diseases, leprosy, blisters, indolent ulcers, conjunctivitis, inflammations, burning sensation and malarial fever [30]. Latex is massaged on body to get relieve of rheumatic pain, thin liquid is applied on eye for eye infection [46].

Medicinal importance of *A. mexicana* whole plant

The whole plant of *A. mexicana* is effective in guinea-worm infestations, purgative and diuretic. This plant is widely used to cure venereal sores, photophobia, scorpion bite, leucorrhoea. Whole plant is used to treat dental disorders [47]. The whole plant, roots, leaves, stem, flowers are extensively used in traditional system of medicine for leprosy, malaria, jaundice, rheumatism, pain, inflammation, skin diseases, fever, piles, warts, dysentery, tumours and worm infestations. The plant is diuretic, purgative and destroys worms and it is also effective in wound healing. The plant is analgesic, antispasmodic, possibly hallucinogenic and sedative. *A. mexicana* helps in the enrichment of blood which acts as an expectorant and aphrodisiac. It is also used in treating skin diseases and leucoderma [48]. The drug prepared from this plant is very effective in treating the problem caused by tape worm. The plant is reported to be used for the treatment of whooping cough and bronchitis. The plant is also used as healing agent in the treatment of malaria, warts, cold sores, skin diseases and itches [49] and contains alkaloids similar to those in the opium poppy (*Papaver somniferum*) and hence can be used as a mild pain-killer. The ethanol extract of the entire plant is reported to possess antiviral, hypotensive and smooth muscle stimulant activity and found to be active against *Proteus vulgaris,Sarcina lutea, Staphylococcus aureus, Candida albicans, Escherichia coli, Pseudomonasaeruginosa, Salmonella newport, Shigella flexneri, Staphylococcus albus* and *Serratiamarcescens*. The plant showed significant effect on the healing of duodenal ulcers induced by Cysteamine hydrochloride [50].

Medicinal importance of *A. mexicana* oil

The oil is useful in indolent ulcers, wounds, leprosy, skin diseases, constipation, flatulence, colic and rheumatalgia [30].

The economic importance of *A. mexicana* according to the medical systems (Unani, Ayurveda, Ethnobotony (Traditional and Folk), Western, Homeopathy, and Chinese) is given in the Table 1.

Phytochemicals

Higher plants are warehouses of assorted bioactive constituents or phytochemicals which find ample use in the pharmaceutical industry. About a quarter of all prescribed pharmaceuticals in advanced countries contain compounds that are directly or indirectly, derived from plants. Phytochemicals or secondary metabolites usually occur in complex mixtures that differ among plant organs and stages of development [51]. Knowledge of the phytochemical constituents is very essential to enable investigation of the actual effectiveness of the plant in medicine. *A. mexicana* is known to possess a wide range of phytochemical constituents which are mentioned below. Table 2 gives the details of the phytochemical constituents that have been reported from different parts of *A. mexicana*.

A large number of chemical constituents have been identified from various parts of *A. mexicana* including Isoquinoline alkaloids, Alkaoids, Aliphatic and Phenolic compounds, Amino acids and Fatty acids and the constituents of pharmacological importance are presented in Table 3 and 4 [52, 53, 54, 55, 56]. Quaternary alkaloids of *A. mexicana*: Four quaternary Isoquinoline alkaloids, Dehydrocorydalmine, Jatrorrhizine, Columbamine, and Oxyberberine, have been isolated from whole plant and their structures established by spectral evidence. This is the first report of these alkaloids (Dehydrocorydalmine, Jatrorrhizine, Columbamine, and Oxyberberine) from *A. mexicana* and *Argemone* genus [57, 56].

Biological activity

Reports on the biological activities are many. The alkaloid Sanguinarine has been reported to prolong ventricular refractoriness and this property may be useful in treatment of ventricular arrhythmias. Plants are known to produce a variety of compounds which have evolved as defence compounds against microbes and herbivores. The elaboration on the biochemically active ingredients and the medicinal properties of *A. mexicana* elicits queries on the effect of plant extracts on other biological organisms. *A. mexicana* has shown promise as an effective bio-control agent. The extracts of *A. mexicana* possess inhibitory, deterrent or lethal activity on biological agents that cause disease and damage to other organisms. Table 5 summarises the effect of *A. mexicana* on different pathogens and pests. Table 6 shows the quick look at the bioactive compounds from *A. mexicana.*

Toxicity and safety evaluation

The alkaloid Sanguinarine isolated from seeds of *A. mexicana* was examined for its hepatotoxic potential in rats. The studies showed that a single dose (10 mg/kg) of Sanguinarine not only increased the activity of Serum Glutamic-Pyruvic Transaminase (SGPT) and Serum Glutamic-Oxaloacetic Transaminase (SGOT) substantially but also caused a significant loss of microsomal cytochrome P-450 and benzphetamine N-methylase activity. Furthermore, the treated rats exhibited considerable loss of body and liver weight, peritoneal edema and slightly enlarged livers with fibrous material. Microscopic examination of the liver tissue showed progressive cellular degeneration and necrosis further substantiating that Sanguinarine is a potential hepatotoxic alkaloid [2]. Toxicolethal effects of seeds of *A. mexicana* were investigated in to roof rat, (*Rattus rattus* L). The *Argemone* seeds were fed at 100% of the diet up to the death or for a maximum of 10 days. Observed signs of poisoning were sedation, passiveness, sluggishness, feeble or no muscular jerks, abdominal contractions and increased defecation.

Also black secretions from the eyes, corneal opacity, erection of hairs, and edema of the hind legs and submandibular space in were noted. Fourteen of 16 rats died. Significant reduction in the weights of the rats was observed. There were significant increases in blood glucose, Blood Urea Nitrogen (BUN) and SGOT. Major histopathological lesions were: hepatocytolysis, nuclear degeneration, pyknosis, cloudy swelling and dilated sinusoids disturbing the lobular architecture of the liver; proliferated endothelium of glomeruli, haemorrhage in glomeruli and interstitial, and cloudy swelling of convoluted tubular epithelium in the kidney cortical region; erosion and atrophy of the upper stomach mucosa and calcification in the cardiac stomach, and; erosion and congestion of the upper mucosa of the duodenum. No change was noticed in the ileum [57]. Safety evaluation studies on *Argemone* oil (AO) through dietary exposure for 90 days in rats: Epidemic dropsy is a disease caused by the consumption of mustard oil contaminated with AO. During 1998 dropsy in New Delhi, which is so far the largest with more than 3000 victims and over 60 deaths, it was enquired at various scientific and regulatory meetings about the maximum tolerated dose of AO. Animals were given AO in diet at a dose of 0.001%, 0.01%, 0.1%, 0.5% and 1% daily for 90 days and the two control groups received the standard diet with and without 1% mustard oil. A decrease in body weight gain (28–31%) was observed in 0.5% and 1% AO groups; while significant increases in relative lungs and liver weight was noticed in respective doses of 0.01% and 0.1% AO groups as well as in higher dosage animals. Reduction in Red Blood Corpuscles (RBC) count and haemoglobin content ($p < 0.05$) was noticed in 0.01% and 0.1% AO exposed animals. This effect was more pronounced in higher AO doses. Serum marker enzymes including alanine transaminase (ALT), aspartate transaminase (AST), lactate dehydrogenase (LDH) and alkaline phosphatase (ALP) were found to be significantly elevated in 0.01–1% AO groups. Further, a decrease in albumin/globulin ratio (42–78%) was observed in the serum of 0.01% to higher AO dose groups. The levels of serum triglycerides and Very Low Density Lipoprotein (VLDL) cholesterol were found to be enhanced ($p<0.05$) in AO treated (0.01–1.0%) animals. Histopathological changes in lung were observed at 0.01% dose of AO while liver, kidney and heart produced changes at 0.1% AO and above doses. None of the parameters were found to be affected in 0.001% AO treated animals. These results suggest that the no observed adverse effect level (NOAEL) dose of AO is 0.001% in rats and considering a factor of 100 for humans for highly toxic compound, the safe limit of 0.00001% (100 ppb or 100 mg AO /g oil) AO can be implicated which shall contain only 0.55% of Sanguinarine equivalent to 0.6 mg Sanguinarine per gram oil. However, the minimum detectable limit of AO is 5 ppm (equivalent to 5 mg Sanguinarine per gram oil) with the present existing High Performance Liquid Chromatography (HPLC) method, thereby suggesting that mustard oil should be absolutely free from AO contamination [58]. *In Vivo* Deoxy ribose Nucleic Acid (DNA) damaging potential of Sanguinarine alkaloid, isolated from AO, using alkaline Comet assay in mice: Consumption of mustard oil contaminated with AO is well known to cause clinical manifestation referred to as ''Epidemic Dropsy''. Our prior studies have shown that AO produces genotoxic effects in mice 30 Since, Sanguinarine alkaloid is the major component of AO, the in vivo DNA damaging potential of the isolated alkaloid was investigated in blood and bone marrow cells of mice using alkaline Comet assay. Swiss albino male mice were given single intraperitoneal administration of 1.35, 2.70, 5.40, 10.80 and 21.60 mg Sanguinarine alkaloid/kg bwt., while controls were treated with saline in the same manner. The results revealed a dose dependent increase in DNA damage in blood and bone marrow cells following 24h treatment of Sanguinarine alkaloid. All the three parameters of Comet assay including olive tail moment (OTM), tail length and tail DNA showed significant ($p < 0.05$) increases in blood and bone marrow cells at respective doses of 10.80 and 5.40 mg alkaloid/kg bwt. However, some of the parameters were significantly increased even at lower doses of Sanguinarine alkaloid (2.70 mg/kg bwt.). The frequency of cells exhibiting greater DNA damage was found to be increased by Sanguinarine alkaloid in a concentration dependent manner. These results indicate that single exposure of Sanguinarine alkaloid causes DNA damage in blood and bone marrow cells of mice, which could be responsible for the genotoxicity of AO. The present study clearly indicates that Sanguinarine alkaloid, an active ingredient of AO possesses DNA damaging potential in blood and bone marrow cells using alkaline Comet assay. These results fully support the earlier observation that in vivo AO caused genotoxicity by enhancing the frequencies of chromosomal aberrations, micronuclei formation and development of Comets resulting in DNA damage 30. In this regard studies have shown that Sanguinarine forms DNA adducts following metabolism by cytochrome P-450 system under in vitro conditions

[59]. It has been suggested that Sanguinarine may undergo N-demethylation by cytochrome P-450 [57]. Since, Sanguinarine has been shown to cause inactivation of cytochrome P-450; it can be argued that the N- demethylated product of Sanguinarine or any other electrophilic metabolite could be responsible for this effect. The decrease in cytochrome P-450 thereby impairs the elimination of a metabolite of Sanguinarine, identified as benzacridine, in urine and faeces. Although, minimum group of Sanguinarine has been shown to have affinity with b-form duplex DNA by intercalation with a high preference to G-C base pairs nonetheless, it could not reveal genotoxicity in Step-Off Sign (SOS) chromtest using *E. coli* PQ37 in the absence and presence of metabolic activation system. However, it raised the possibility of usage of Sanguinaria extract in toothpaste in the development of oral leukoplakia [60].

Table 1: Economic importance of *A. mexicana* according to various medical systems

Medical Systems	Medicinal uses	References
In Unani	*A. mexicana* helps in the enrichment of blood which acts as an expectorant and aphrodisiac. It is also used in treating skin diseases and leucoderma	[48]
In Ayurveda	Ayurveda or herbal medicine has been in practice since long time as one of the basic treatments for cure of various diseases in India. There are approximately 1250 Indian medicinal plants which are used in formulating therapeutic preparations according to Ayurvedic and other traditional systems of medicine. *A. mexicana* is widely well known around the world for its medicinal property to treat several diseases: in India, decoction of the leaves is indicated for the treatment of bacterial infections and seeds are purgative and sedative. The whole plant of *A. mexicana* is effective in guinea-worm infestations, purgative and diuretic. Seeds of the plant are used as an antidote in snake poisoning and also acts as an emetic, expectorant, demulcent and laxative. The protein-dissolving substances containing seed extract is used to cure warts, cold sores, cutaneous infections, itches, jaundice and dropsy. Seeds are effective against skin infection, sores, dropsy and jaundice. Juice of the plant cures ophthalmic and opacity of cornea. Oil of the seed is used to treat skin diseases. Roots are antihelmentic and also used in, skin diseases, leprosy and inflammations.	[61, 19, 62, 63, 64, 22]
In Ethnobotany (In Traditional)	The plant *A. mexicana* is traditionally used as a potent diuretic agent. It is a pantropical species which has a long history of use in traditional medicine dating back to the Aztecs. In the traditional system of medicine, whole plant of *A. mexicana* is extensively used in the treatment of tumours, warts, skin diseases, inflammations, rheumatism, jaundice, leprosy, piles, warm infestations and dysentery. *A. mexicana* is extensively used in traditional system of medicine in the treatment of numerous diseases. Various parts of the plant were extensively used in Ayurveda, Siddha, Unani and Homeopathic medicines. In Brazil, the plant is commonly known as 'cardo-santo' and used traditionally in the treatment of a number of diseases. It is traditionally used as hallucinogenic, analgesic antispasmodic. In Senegal, this plant is known for its calming, diuretic, cholagogue and wound healing properties. The plant is known to be toxic for animals, and it might cause death due to intestinal bleeding. This is thought to be caused by the latex and the seeds. Because of this, the plant is only used by healers.	[65]
(In Folk)	*A. mexicana* is widely used in folk medicine to alleviate several ailments especially for its analgesic, antibacterial, antimalarial, antispasmodic, sedative and narcotic effects. *A. mexicana* and its constituents are extensively used in traditional and folk medicines for the treatment of skin diseases. The entries regarding the multifarious applications of *A. mexicana* in folk medicine have been grouped regionally to emphasize the ethnobotanical diversity and ubiquity of the plant.	[66, 67]
In Western	*A. mexicana* is reported to have antimicrobial activity, wound healing capacity in rat, larvicidal and chemosterilant activity and nematicidal and allelopathic potential.	[4, 5, 6, 7]
In Homeopathy	In Homeopathy, the tincture of the entire plant is reported to be used orally for bronchitis and whooping cough. The fresh juice of the leaves and the latex, both are reported to be used externally as a disinfectant for open wounds and cuts. The tincture of this plant has a soothing, hypnotic, antispasmodic effect in whooping cough. The Mexican Indians used the juice of this plant to treat corneal opacitities, incipient cataracts and pterigion. Dr. Luis g. de Legarreta made the first provings of this drug. A prover smoked a quantity of the seeds and before he had smoked out his pipe, he fell into a sound sleep; not easily awakened.	[68, 69, 70, 71, 72, 73, 39, 74, 75, 76]
In Chinese	Berberine salt has been used in China to treat arrhythmia and heart failure for years. The capacity of alkaloid to prolong the duration of cardiac action potentials is well known and this effect is mainly attributed to the inhibition of slowly activating components (IKs) and increase of L-type Ca2+ currents in myocytes The alkaloid Protopine has been studied especially in China for its cardiac effects. An antiarrhythmic activity has also been demonstrated by the prolongation of the functional refractory period. An inhibition of spontaneous beat and contractive force were also observed.	[77, 78, 79, 80]
Economic importance	The economic importance of *Argemone* weed plant could be concluded as sources of oil, alkaloids and renewable energy The non-edible oil called *A. mexicana* oil, a weed crop, has a potential to become a suitable alternative fuel for ever depleting fossil fuels.	[81, 24, 82, 83, 84, 85, 86]

Table 2: Phytochemical constituents of different parts of *Argemone mexicana*

Plant parts	Phytochemical constituents (Alkaloids)	References
Apigeal parts	Isocorydine; Allocryptopine; (-)-Cheilanthifoline; (-)-Scoulerine	[87, 88, 89]
Apigeal parts,	Berberine; Protopine	[87, 88, 89, 90, 91, 92]

seeds		
Whole plant	Dehydrocheilanthifoline; Dehydrocorydalmine; Jatrorrhizine; Columbamine; Coptisine; Cryptopine; Muramine; Argemexicaine A; Argemexicaine B; (+)-Cheilanthifoline; (-)-Stylopine; Nor-Sanguinarine; Chelerythrine; Oxyhydrastinine; Thalifoline; Argemexirine; (±)-Tetrahydrocoptisine; (-)-Tetrahydroberberine; Dihydrocoptisine; Oxyberberine; *O*-Methylzanthoxyline; Nor-Chelerythrine; Arnottianamide; (±)-6-Acetonyl dihydrochelerythrine; Angoline; 8-Acetonyl dihydrosanguiranine	[9, 10, 88, 89, 90, 92, 93, 94, 95, 96]
Apigeal parts, Aerial parts	(+)-Reticuline	[9, 87, 88]
Aerial parts	Protomexicine; 13-Oxoprotopine; (+)-Argenaxine; (+)-Higenamine; *N*-Demethyloxysanguinarine; Pancorine; 8-Methoxy dihydrosanguiranine	[96, 97]
Seeds	Sanguinarine; Dihydrosanguiranine; Dihydropalmatine hydroxide	[88, 89, 90, 91, 96]
Tissues	Dihydrochelerythrine	[96]
	(Terpenoids)	
Aerial parts	*Trans*-phytol	[96]
Leaves	β-amyrin	[98]
	(Steroids)	
Aerial parts	Stigma-4-en-3,6-dione	[96]
Roots	β-sitosterol	[99]
	(Carbohydrates)	
-	Lactose	[100]
-	Arabinose	[100]
	(Long-chain alcohols)	
Aerial parts	Triacotan-11-ol; Triacotan-6, 11-diol (mexicanol); Mexicanic acid	[101, 102]
Flowers	Hentriacontane-3,20-diol	-
Seeds	11-Oxo octacosanoic acid; 11-Oxo triacontanoic acid; 9-Oxo octacosanoic acid	[103, 13, 91]
Oil	(+)-6-Hydroxy-6-methyl-9-oxo-octacosanoic acid (argemonic acid); Myristic acid (tetradecanoic acid); Palmitic acid; Stearic acid; Arachidic acid; Oleic acid; Linoleic acid	[104, 105]
	(Amino acids)	
Leaves	Cysteine; Phenylalanine	[98]
	(Flavonoids)	
Seeds	Luteolin; Eriodictyol	[12]
Leaves, flowers	Isorhamnetin-3-*O*-β-Dglucopyanoside	[96, 98, 103, 106, 107]
Flowers	Isorhamnetin; Isorhamnetin-7-*O*-β-Ddiglucopyanoside; Isorhamnetin-3,7- *O*-β-Ddiglucopyanoside	[99, 103, 106]
Whole plants	Quercetin	[108]
Aerial parts	Quercetrin; Mexitin	[97]
Whole plants, aerial parts	Rutin	[108, 97]
	(Phenolics and aromatic acids)	
Seeds	5,7-Dihydroxy chromone-7-neohesperidoside	[117]
-	Tannic acid; Caffeic acid; Ferulic acid; Benzoic acid; Cinnamic acid	[110]
Flowers	Vanillic acid	[99]
	(Miscellaneous)	
Aerial parts	α-Tocopherol; Adenosine; Adenine	[96]
Seeds	Benzphetamine *N*-demethylase; Sn-glycerol-1-eicosa-9,12-dienoate-2-palmitoleate-3- Linoleate	[2, 111]

Table 3: Phytochemicals present in *A. mexicana* leaves

Isoquinoline Alkaloids	Alkaloids	Aliphatic Compounds	Phenolic Compounds
Cheilanthifoline	Berberine	Mexicanol	Eriodictyol
Coptisine	Protopine	Mexicanic acid	Argemexitin 5, 7- neohesperidoside
Cryptopine	Sarguanerine		
Muramine	Muramine		
Scoulerine	Chelerytherine		
Stylopine			
Thalifoline			
Dihydropalmitine hydroxide			
Oxyhydrastinine			

Table 4: Phytochemical Evaluationof *A. mexicana*

Parts	Constituents isolated
	(Alkaloids)
Whole plant	*N*-Demethyloxysanguinarine; Pancorine; (+)-Argenaxine; (+)-Higenamine; (+)-Reticuline; Chelerythrine; Angoline; *O*-Methylzanthoxyline; Norchelerythrine; Sanguinarine; 6-Acetonyldihydrosanguinarine; 6-Acetonyldihydrochelerythrine; Aronttianamide; Berberine; Dihydrocheilantifoline; Protopine; Allocryptopine; Coptisine; Dehydrocorydalmine; Jatrorrhizine; Columbamine; Oxyberberine.

Table 5: Activity of *A. mexicana* extracts on biological pathogens and pests

Activity	Action against	References
Anti-bacterial	*Bacillus subtilis, S. aureus, Listeria monocytogenes, Clostridium botulinum, Clostridium perfringens, E. coli, P. aeruginosa and Salmonella typhimurium* (Food born gram positive and gram negative bacteria). *Enterococcus* sp. *Klebsiella oxytoca, Vibrio damsella, Enterobactor aerogens, Streptococcus mutans, Porphyromonas gingivalis, Klebsiella pneumonia, Bacillus cereus, Streptococcus agalactiae*	[19, 112, 113, 114, 115, 116, 117, 118, 119, 120]
Anti-inflammatory	Mice, Rats	[121, 98]
Wound healing	Animals, albino rats, Wistar albino rats	[5]
Anti-stress and antiallergic	Albino mice	[83]
Vasoconstrictor and vasorelaxant effects	Rat aortic rings	[122]
Anti-fertility	Spermatogenesis in dogs	[123]
Cytotoxic	Healthy mouse fibroblasts and three human cancer-cell lines, Human nasopharyngeal carcinoma and human gastric cancer-cell lines	[96]
Nematicidal	*Meloidogyne incognita* (Larvae), *M. Juvanica*	[124, 125, 126, 7]
Antifeedant	Second stage larvae of *Henosephilachna vigintiocta puncata* Fabricius	[127]
Lousicidal	*Tropicalis peters*	[128]
Mollucicidal	*Lymnaea acuminata* and nervous tissue of treated Snails	[129]
Effect on ileum organ	Morphine withdrawal effect in Guinea pig isolated ileum	[130, 131]
Fungitoxic	*Trichophyton mentagrophytes*, Fruit pathogens like *Alternaria alternata*, *Dreschlera halodes* and *Helminthosporium speciferum, Curvularia tuberculata*	[132, 133, 134, 135]
Anthelmintic	Indian Earthworm, *Pheritima posthuma, Ascardia galli*	[136, 137]
Larvicidal	2nd instar larvae of *Aedes aegypti*, 3rd -4th instar larvae of *Culex quinquefasciatus*	[6, 15, 138]
Antioxidant	DPPH (85.17%0, ABTS (75.27%) and H_2O_2 (84.25%) radicals	[35]
Anticancer	Human cancer cell lines such as HeLa-B75 (48%), HL-60 (20.15%) and PN-15 (58.11%), HeLa and MCF-7 Cancer cell lines	[139, 140]
Antidiabetic	Alloxan induced diabetic rats, Streptozotocin induced hyperglycemic Wistar albino rats	[141, 142]
Antihepatotoxic	Carbon tetrachloride-induced hepatotoxic male albino rats; CC14-induced hepatotoxicity in Wistar rats	[23]
Anti-parasite	Chloroquine-resistant K1 strain of *Plasmodium falciparum*	[143]
Analgesic, Locomotor and muscle relaxant	Wistar albino mice	[144]
Anti-termitic	Formosan subterranean termite pest, *Coptotermes formosanus* Shiraki	[145]

Table 6: A quick look at the bioactive compounds from *A. mexicana*

Compound	Biological activity	References
Berberine	Anti-fertility activity,	[123]
	Effect on Ileum contraction in guinea pig	[131]
Dehydrocorydalmine	Antifungal activity	[94]
(+)-Reticuline	Cytotoxic activity	[96]
Protopine	Anti-fertility activity,	[123]
	Effect on ileum in guinea pig	[130, 131]
	Mollucicidal activity	[129]
Allocryptopine	Effect on ileum in guinea pig	[130, 131]
Chelerythrine	Cytotoxic activity	[96]
Sanguinarine	Mollucicidal activity	[129]
(+)-Argenaxine	Cytotoxic activity	[96]
(+)-Higenamine	Cytotoxic activity	[96]
Oxyberberine	Antifungal activity	[94]
N-demethyloxysanguinarine	Cytotoxic activity	[96]
Pancorine	Cytotoxic activity	[96]
(±)-6-Acetonyl dihydrochelerythrine	Anti-HIV activity	[88]
Angoline	Cytotoxic activity	[96]
Dihydropalmatine hydroxide	Anti-fertility activity	[123]
β-Amyrin	Anti-inflammatory & analgesic activity	[98]
Cysteine	Anti-inflammatory & analgesic activity	[98]
Phenylalanine	Anti-inflammatory & analgesic activity	
Isorhamnetin-3-*O*-β-D-glucopyanoside	Anti-inflammatory & analgesic activity	[98]

CONCLUSION

Numerous studies have been conducted on different parts of *A. mexicana* and proved that the plant can be exploited for the development of new drugs. A detail pharmacological study is required.

CONFLICT OF INTERESTS

Declared None

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