

ARGEMONE MEXICANA A HIDDEN MEDICINAL PLANT AND TO EVALUATE ITS EDIBILITY

Abstract

Plants are called the natural healer, and even not a single plant is futile on the earth. Our nature is usually blessed with many plants and every plant contains medicinal properties either in the explored or unexplored way. Some of the plants are either edible or maybe toxic but are rich in phytochemicals, which help in the treatment of many diseases and help mankind to survive for a long time. One of them is *Argemone mexicana*. The plant belongs to Papaveraceae popularly known as the poppy family. The plant is generally called a Mexican prickly poppy or Ghamoya. This weed is habitually ignored, but the number of studies remarkably shows a range of beneficial health issues. Traditionally the entire plant, leaves, seeds, stems, and roots are widely used in Ayurveda, Unani, and Siddha to treat several dermal issues, itching, inflammation, tumors, jaundice, microbial infection, leprosy, and malaria. The plant contains phytochemicals such as terpenoids, alkaloids, flavonoids, phenolics, and aliphatic alcohols. The plant is known as toxic due to the presence of sanguinarine alkaloids. However, the edibility of the seed oil is still doubtful due to its alkaloid. Besides this, the seed oil from this plant is mostly contaminated with mustard oil which may lead to several health issues, worldwide known as epidemic dropsy. This chapter contains recent information that may be helpful for further investigation on the plant *Argemone mexicana*.

Keywords: *Argemone mexicana*; Ghamoya; Mexican prickly poppy; Sanguinarine; berberine; epidemic dropsy, medicinal plant

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I. INTRODUCTION

Treating with the medicinal plant is as old as the Indian civilization. India is well known for the utilization of the plant from ancient times as a folklore medicine. From the beginning, the association between man and his search for medicinal plants from nature has been documented in many traditional medicinal books. The usage of medicinal plants is a result of many years of practice, struggle, and experience against illness. They learned how to use the bark, leaves, flowers, fruits, seeds and roots, and many more parts of the plant as a drug. Nowadays also many compounds are being isolated for treating various diseases. Medicinal plants are more successful due to their less virulent and side effects than synthetic drugs [1,2].

Argemone mexicana is popularly known as Ghamoya or Mexican prickly poppy. The plant belongs to the family Papaveraceae and is an annual, local exotic weed in South America, but extensively exist in many tropical and subtropical parts of West Africa [3,4]. In India, it grows as a weed in cultivated fields, wastelands, and on the roadside [2]. *Argemone mexicana* is appraised as a crucial therapeutic plant. The plant is an annual, erect, and spiny herb. The stem of the plant is slightly grayish-white, branched and extremely prickly, and grows up to 100-140 cm. When the plants get injured, a yellow latex is discharged. The leaves of the plant are sessile, exstipulate, alternate, without petioles, unicostate reticulate venation, spiny margin, and deeply lobed. The leaves are also greyish white in color. The flowers are more showy, large, and yellow in color with a diameter of 2.5-5 cm. The flowers are complete, hermaphrodite, pedicellate, and hypogynous. The corolla of the flower has 6 petals with yellow coloration and is polypetalous. The calyx of the flower has 3 sepals, polysepalous and twisted. The fruit of *A. mexicana* is capsulated and spiny with greyish white in color. It contains blackish-brown tiny spherical seeds with a diameter of 1 mm. The seeds are looking similar to a mustard seed and are shiny. The roots are white, long and subcylindrical [2,5]. **Table 1** depicts the taxonomical classification and **Table 2** Vernacular names of *Argemone mexicana*.



Table1:Taxonomical Classification [5]

Kingdom	Plantae
Superdivision	<i>Spermatophyta</i>
Division	<i>Magnoliophyta</i>
Class	<i>Magnoliopsida</i>
Subclass	<i>Magnoliidae</i>
Order	<i>Papaverales</i>
Family	<i>Papaveraceae</i>
Genus	<i>Argemone</i>
Species	<i>Argemone mexicana</i>

Table 2:Vernacular names [2,5]

English	Mexican Prickly Poppy
Sanskrit	Brahmadandi, Pitopushpa, Hemavati Srigalkanta, Hemadugdha, Svarnakshiri
Hindi	Shialkanta, Satyanashi, Bharbhand, Peela kanteela
Rajasthani	Satyanashi, Daturi
Gujrati	Darudi
Marathi	Daruri, dhotara, Kontedhotra, Firangi-kote-pavola
Malayalam	Ponnummattu, Kantankattiri
Telugu	Brahmadandi
Tamil	Brahmadandu, Kurukkum

- Habitat and Distribution:** The species of the plant are generally found in all regions of the world. Africa (such as Namibia, Nigeria, South Africa, Sudan, Zimbabwe, Somalia, and many more), Middle East (Turkey, Saudi Arabia, Israel, Syria, Iran, and Iraq), South America (Brazil, Argentina, Columbia, Peru, Chile, Bolivia, Ecuador), North America (Canada, USA, Hawaii, Anguilla, Barbados, Belize, Antigua), Oceania (New Zealand, Fiji, Australia), Europe (Spain, UK, Italy, Switzerland), Asia (China, Cambodia, Japan, Hong Kong, Pakistan, Indonesia, Bangladesh, Bahrain, Bhutan, Java) [6]. In India, the plant species is popular in the states like Bihar, Uttar Pradesh, West Bengal, Assam, Andhra Pradesh, Madhya Pradesh, Gujarat, Tamil Nadu, Karnataka, Maharashtra, and Rajasthan [6,7].
- Traditional Uses:** *mexicana* is extensively used as traditional medicine in the remedy for several diseases. The entire plant is utilized extensively in Ayurveda, Unani, Siddha, and Homeopathy. In Ayurvedic medicine generally, the entire plant part is used. The plant is

effective in diuretics, purgative, and worm infestation. The seeds are used as antidotes in snake poisoning. It is used to cure skin infections, Jaundice, cold sores, and dropsy. Whereas the oils used in dermal problems. The yellow juice from the plant is used to cure corneal opacity and ophthalmic problems. The root is effective in dermatitis and in leprosy [8,9].

In Siddha medicine, the plant is used to treat Scorpion bites, leucorrhoea, photophobia, and many more disease. The leaves in addition to pepper are used to control the blood glucose level. The decoction prepared from *A. mexicana* leave is used in ulcer and malarial fever. The seeds are used in dropsy, jaundice, and in leprosy. The yellow stem juice is effective against boils and scorpion stings [10,11]. In Unani medicine, it is used as lascivious and expectorant and in several dermal problems, whereas in Homeopathy the plant is used in tap worm treatment and is also effective in bronchitis and whooping cough [2].

- 3. Phytochemical Constituent:** A large number of Phyto-components have been extracted from *Argemone mexicana*, and reported to possess alkaloids, flavonoids, terpenoids, amino acids, fatty acids, phenolic, and long-chain aliphatic compounds. The plant is known to contain four types of quaternary alkaloids dehydrocorydalmine, jatrorrhizine, columbamine, and oxyberberine [12]. The isoquinoline alkaloid such as sanguinarine, berberine, optisine, protopine, cheilanthifoline, scoulerine methohydroxide, benzyl-isoquinoline, chelerythrine, Coptisine, muramine, allocryptopine, stylophine methohydroxide and thalifone [2,13]. The plant known to contain aliphatic compounds such as mexicanol and mexicanic acid [6]. The seed oil known to contain sanguinarine and dihydrosanguinarine along with some fatty acids such as oleic acid, linoleic acid, myristic acids and palmitic acid [2]. See **table 3** for phytochemical constituent of seed, aerial part, whole part and an epigeal part of *Argemone mexicana* plant.

Table 3: Phytochemical Constituent of *Argemone mexicana* [14]

	Epigeal part	Aerial part	Whole part	Seed
Alkaloid	Isocorydine, berberine, reticuline, protopine, allocryptopine, cheilanthifoline, scoulerine,	Reticuline, N-demethyloxysanguinarine, pancorine, 8-methoxy dihydrosanguinarine, protomexicine, 13-oxoprotopine, argenaxine, higenamine,	Dehydrocheilanthifoline, jatrorrhizine, cryptopine, argemexicaine A, argemexicaine B, stylophine, chelerythrine, oxyhydrastinine, argemexirine, dehydrocorydalmine, columbamine, coptisine, muramine, dihydrocoptisine, cheilanthifoline, O-methylzanthoxyline, nor-chelerythrine, arnottianamide, 6-	Berberine, protopine, sanguinarine, dihydrosanguinarine, dihydropalmatine hydroxide

			acetyl dihydrochelerythrine, tetrahydrocoptisine, norsanguinarine, angoline, 8-acetyl dihydrosanguiranine, thalifoline, tetrahydroberberine, oxyberberine,	
Terpenoid		trans-phytol, β - amyrin		
Steroid	β -sitosterol (root)	stigma-4-en-3,6- dione		
Long-chain alcohol		hentriacontane-3,20- diol (flower), triacotan-6, 11-diol (mexicanol), triacotan-11-ol		9-oxo octacosanoic acid, 11- oxo triacontanoic acid, 11- oxo octacosanoic acid,
Flavonoids		isorhamnetin-3-O- β - D-glucopyranoside (flower and leaves), isorhamnetin-7-O- β - D-diglucopyranoside (flower), rutin, mexitin, isorhamnetin (flower), isorhamnetin-3,7- O- β -D- diglucopyranoside (flower), quercetin	Quercetin, rutin	Luteolin, eriodictyol
Phenolics & aromatic acids		vanillic acid (flower)		tannic acid, ferulic acid, cinnamic Acid, 5,7- dihydroxy chromone - 7- neohesperid oside, caffeic acid, benzoic acid

II. PHARMACOLOGICAL ACTIVITY

- 1. Hepatoprotective Activity:** The aqueous and methanolic extract of the aerial part was used to evaluate the hepatoprotective effect of *Argemone mexicana* on the rat model. An equal volume (3ml/kg) of olive oil and CCl₄ was injected intravenously for hepatic injury. The different doses of extract sample were given to the rat model, the aqueous extract (400mg/kg/day) and methanolic extract of (100, 200, and 400mg/kg/day) for five days where CCl₄ was introduced on the third day. The methanolic extract of 100mg/kg/day was found more significant ($p < 0.05$) and hepatoprotective. The dose was effectively lowered the Serum Glutamate Pyruvate Transaminase (SGPT), Serum Glutamate Oxaloacetate Transaminase, and Alkaline Phosphatase (ALP). The histopathological report shows regeneration and healing of hepatic cells at the same dose. So, it proves that *Argemone mexicana* possesses hepatoprotective activity. [15]. The aqueous and crude leaf powder suspension shows an anti-hepatitis effect when the suspension of 250mg/kg body weight was introduced orally in a rat model [16].
- 2. Antiplasmodial Activity:** The berberine fraction and crude alkaloid extract was isolated from the leaves of *A. mexicana*. An in-vitro study of crude alkaloid extract (73.84 $\mu\text{g/ml}$) and berberine (34.18 $\mu\text{g/ml}$) shows Antiplasmodial activity against *Plasmodium falciparum*. The Brine Shrimp lethality method was used to monitor the toxicity of both extract samples and found no toxicity at that dose. The crude alkaloid extract was more effective than berberine in-vivo activity against *Plasmodium berghei* in the mice model. So, the above results show that *Argemone mexicana* can be used in malaria treatment with more advanced research [17].
- 3. Anti-inflammatory Activity:** The alcoholic extract of *Argemone mexicana* is assessed to possess analgesic and anti-inflammatory activity. The result shows that the ethanolic extract of 200mg/kg in mice was more effective [18]. The leaf extract of *Argemone mexicana* also possesses anti-inflammatory activity. Many studies report this is due to the presence of phytoconstituents such as isorhamnetin-3-O- β -D-glucopyranoside, phenylalanine, cysteine, and β -amyryn [19,14].
- 4. Wound Healing Activity:** Different solvent extracts were reported to possess the wound healing activity of *Argemone mexicana* in the rat model. The wound healing activity was done by incision, excision, and on dead space of wound rat. The result shows the alcoholic extract of leaves promotes wound healing effect [20]. The in vivo study of leaf extract and latex was used to assess these activities in a rat model. The wound activity from extract and latex was more effective than the drug (nitrofurazone) used in the study. The extract treated model found higher tensile strength than the latex treated model [21].
- 5. Ant-microbial Activity:** The methanolic, chloroform, and petroleum ether leaves extract were used to assess the anti-microbial activity of *Argemone mexicana*. The result shows that the methanolic extract possessed a more antibacterial effect than the chloroform and petroleum ether extract. The minimal inhibitory concentration (MIC) against the bacterial strain was found in the range of 125-1000 $\mu\text{g}/\mu\text{l}$ [22]. The different solvent stem extracts (chloroform, hexane, ethanol, and ethyl acetate) were used to evaluate the anti-microbial activity of *A. mexicana*. The MIC and agar diffusion methods were used against bacteria (such as *Staphylococcus aureus*, *Clostridium perfringens*, *Clostridium botulinum*,

Campylobacter jejuni, *Escherichia coli*, *Bacillus subtilis*, *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Vibrio cholerae*, and *Salmonella typhimurium*) The organic extract of 10µl was effective against *Staphylococcus aureus*, *Escherichia coli*, *Clostridium botulinum*, *Clostridium perfringens*, *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, and *Salmonella typhimurium*. The MIC value was from 62.5 - 500 µg/ml and the zone of inhibition against the tested bacteria range from 10.1-21.4 mm.

The chloroform seed extract of *Argemone mexicana* shows antimicrobial activity. The seed dose of 500 mg/ml shows antimicrobial activity against *Salmonella typhi*, *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* with the MIC range of 2 to 5 mg/ml [23]. The methanolic fruit extract of *Argemone mexicana* at the same dose of 500 mg/ml was found more effective against *Staphylococcus aureus*, *Salmonella typhi*, and *Pseudomonas aeruginosa*, whereas the methanolic fruit extract had a strong effect against gram-negative bacteria in the study [24].

The aqueous and ethanolic extract of the plant is effective against oral cavity infection inducing bacteria (*Porphyromonas gingivalis* and *Streptococcus mutans*). The aqueous extract was effective against *Porphyromonas gingivalis* and the alcoholic extract was effective against *Streptococcus mutans* with MIC values of 78 and 125 µg/ml [25]. The different solvent extracts (aqueous, chloroform, ethanol, and acetone) prepared by using leaves, stem, and roots were found effective against the bacterial strain named *Klebsiella pneumonia*, *Staphylococcus aureus*, *Bacillus cereus*, and *Escherichia coli*. The study shows that the stem extract possesses a stronger antimicrobial effect than the leaves and roots. The ethanolic stem extract was found more effective against the bacteria *Klebsiella pneumonia* (inhibition zone 22.86 mm) [26]. Some alkaloids (Oxyberberine and dehydrocorydalmine) from *Argemone mexicana* showed antifungal activity against *Curvularia* sp., *Fusarium udum*, *Bipolaris* sp, *Helminthosporium* sp, and *Alternaria cajani*. All of these fungi were significantly inhibited at the concentration of 1000-5000 ppm [27].

6. **Antistress and Antiallergic activity:** The aqueous and methanolic stem extract (at a dose of 50mg/kg of model mice) of *A. mexicana* was reported to exhibit antistress and antiallergic function. The effectivity was assessed in asthma produced by milk-induced eosinophilia and leucocytosis in a mice model. Both the extract was able to reduce significantly ($p < 0.05$) eosinophils and leucocytes [28].
7. **Antifertility Activity:** The isoquinoline alkaloids (such as protopine, berberine, and dihydro palmatine hydroxide) were extracted from seeds of *A. mexicana*. These isoquinoline alkaloids were reported anti-spermatogenic function in dogs. When the dog was fed for 70 days at a dose of 30 mg/kg found late spermatid formation. The spermatid was found to reduce at first 46.5 % then 58% and at last, it was reduced to 97.7%. The spermatids were reduced due to protopine, berberine, and dihydro palmatine hydroxide, whereas the cells of Leydig were reduced due to berberine and protopine [14].
8. **Cytotoxic Activity:** The alkaloids (pancorine, angoline, N-demethyloxysanguinarine, reticuline, chelerythrine, argenaxine and higenamine) from *Argemone mexicana* were used to evaluate the cytotoxic activity against nasopharyngeal carcinoma and gastric human

cancer cell lines. Among all the alkaloids, the chelerythrine was found more effective against gastric cancer cells, whereas angoline was found effective against both cancer cell lines [29].

9. **Larvicidal Activity:** The petroleum ether seed extract from *A. mexicana* shows growth-inhibiting and larvicidal activity against *Aedes aegypti* at the concentration having IC₅₀ values of 17.43 and 13.58 ppm under laboratory and field conditions. [30]. The petroleum ether leaf extract shows high larvicidal activity (of 48.89 ppm) against *Culex quinquefasciatus*[31].
10. **Antihelmintic Activity:** The aqueous and alcoholic extract of *Argemone mexicana* (aerial part) was found to show an antihelmintic effect against *Pheritima posthuma* (an Indian earthworm)[32]. The aqueous and alcoholic leave extract also shows antihelmintic activity (at a dose of 100mg/ml) against *Pheritima posthuma* and *Ascaridia galli* [33].
11. **Antidiabetic Activity:** Ethanolic and Aqueous extract of epigeal part of *A. mexicana* was used to assess the hypoglycaemic effect on the alloxan-induced rat model. Both the extract when introduced orally (200 and 400 mg/kg body weight). The result indicates that the normal glycemic rat reduced the blood glucose level from 3-12 % and the hyperglycaemic rat showed a significant ($p < 0.05$ to 0.001) blood sugar fall [34]. The hydro-alcoholic extract of *A. mexicana* was used to assess the antihyperglycemic effect. The extract dose (200 and 400 mg/kg body weight), when introduced to streptozotocin-induced rats, shows to reduce blood glucose levels. The result showed that the extract dose of 400 mg/kg body weight was prominent when compared with metformin (300 mg/kg body weight) [35].
12. **Anti-HIV Activity:** The methanolic extract of the entire plant of *A. mexicana* was reported to possess anti-HIV activity. The protopine type alkaloid (benzo[*c*]phenanthridine (\pm)-6-acetyl dihydrochelerythrine) was found to possess that activity in H9 lymphocyte with EC₅₀ value of 1.77 μ g/ml and a therapeutic index of 14.6 respectively [36].

III. EDIBILITY OR TOXICITY

The seed oil of *Argemone mexicana* is known to contain toxic alkaloids. This quaternary benzo phenanthridine alkaloid possesses 90% sanguinarine and 5% dihydrosanguinarine along with some amount of coptisine and chelerythrine. It also contains less amount of isoquinoline alkaloid (protopine and berberine). The seed of *Argemone mexicana* contains 30 to 35% oil, the protein content of 24%, oleic acid (21-33%), linoleic acid (54-61%), and 0.13% alkaloids. However, the edibility of the seed oil is still doubtful due to its alkaloid. But the oil is used in many other non-edible purposes such as soap formation, biodiesel, and pesticide preparation [39].

The seed oil of the plant was found more toxic results in animal models, and the toxicity is assumed due to the presence of sanguinarine alkaloid. The alkaloid is reported two to three times more poisonous than its dihydrosanguinarine form. Both alkaloids exist in inter-convertible form due to the oxidation and reduction process. In many results, it has been proven these alkaloids were responsible for epidemic dropsy and glaucoma. The epidemic

dropsy is a disease of neuroparalysis and death in most cases. The exact mechanism of toxicity of the seed oil is not known clearly but is supposed to happen due to Na^+/K^+ ATPase inhibition, cell membrane destruction due to lipid peroxidation and reactive oxygens, DNA polymerase inhibition, and increases glycogenolysis that results in pyruvate accumulation (which causes capillary dilation)[14,37]. The alkaloid (sanguinarine) shows a hepatotoxic effect in the many rat model experiments. Even, a very small dose (10 mg/kg) of the alkaloid actively increases the SGPT and SGOT and decreases microsomal cytochrome P-450 and the activity of the enzyme benzphetamine N-demethylase. Treated rat models found reduced body and liver weight, hepatic inflammation, and ascites. Hepatic tissue damage and their necrosis[38].

The seed was occasionally contaminated with cereals, but mostly its oil is contaminated with edible oils. Especially with mustard (*Brassica nigra*) oil because both the seeds look similar. The consumption of the oil contaminated with *Argemone mexicana* (Mexican poppy seed) and *Brassica nigra* (mustard seed) may lead to epidemic dropsy. In the year 1996, many cases of epidemic dropsy were reported in many states of India [40]. The epidemic dropsy may lead to proliferation, dilatation, and increased permeability of capillaries. These effects may cause edema in the lower body and limb, rapid oxidative stress, and rapid destruction of RBCs that leads to anemia and at last congestive heart failure. The consumption of contaminated oil may lead to visible symptoms such as acute diarrhea, vomiting, coughing, erythema, and shortness of breath [40].

IV. CONCLUSION

The present chapter aims to deal with up-to-date findings of a phytochemical constituent, pharmacological activity, edibility, and the toxicity effect of *Argemone mexicana*. The plant is popularly known as the Mexican prickly poppy or Ghamoya. The plant is used to treat several diseases such as dermal disease, rheumatism, tumors, inflammation, microbial infection, leprosy, malaria, jaundice, and many more. The plant is known to contain carbohydrates, proteins, fats, and phytochemicals such as terpenoids, alkaloids, flavonoids, phenolics, and aliphatic alcohols. Besides the pharmacological activity, the plant shows its toxicity as well. This review broadly discussed the toxicity of the plant and its constituents responsible for that. It also focused on the adulteration of prickly poppy seed with mustard oil that caused epidemic dropsy in different parts of the world. This chapter contains recent information that may be helpful for further investigation on the plant *Argemone mexicana*.

REFERENCE

- [1] Petrovska BB. Historical review of medicinal plants' usage. *Pharmacognosy reviews*. 2012 Jan;6(11):1.
- [2] Priya CL, Rao KV. Ethanobotanical and current ethanopharmacological aspects of *Argemone mexicana* Linn: an overview. *International Journal of Pharmaceutical Sciences and Research*. 2012 Jul 1;3(7):2143.
- [3] Khare CP. *Indian medicinal plants: an illustrated dictionary*. Springer Science & Business Media; 2008 Apr 22.
- [4] Ibrahim HA, Ibrahim H. Phytochemical screening and toxicity evaluation on the leaves of *Argemone mexicana* Linn. (Papaveraceae). *International Journal of Applied Sciences*. 2009;3:39-43.
- [5] Verma S. Phytochemical and pharmacological study on *Argemone mexicana* Linn (Papaveraceae). *Int J Pharm*. 2017;7(1):90-3.
- [6] Alam A, Khan AA. *Argemone mexicana* L.: A weed with versatile medicinal and pharmacological applications. *Ann. Phytomed. Int. J*. 2020;9:218-23.

- [7] Sharanappa R, Vidyasagar GM. Plant profile, phytochemistry and pharmacology of *Argemone mexicana* Linn. A review.
- [8] Osho A, Adetunji T. Antimicrobial activity of the essential oil of *Argemone mexicana* Linn. *Journal of Medicinal Plants Research*. 2010 Jan 4;4(1):019-22.
- [9] Chopra RN, Nayar SL, Chopra IC. *Glossary of Indian medicinal plants with active principles*. Council of Scientific & Industrial Research: New Delhi, India. 1986.
- [10] Alagesabooopathi C. Ethnomedicinal plants and their utilization by villagers in Kumaragiri hills of Salem district of Tamilnadu, India. *African Journal of Traditional, Complementary and Alternative Medicines*. 2009;6(3).
- [11] Ganesan S. Traditional oral care medicinal plants survey of Tamil Nadu.
- [12] Singh S, Singh TD, Singh VP, Pandey VB. Quaternary alkaloids of *Argemone mexicana*. *Pharmaceutical biology*. 2010 Feb 1;48(2):158-60.
- [13] Haisova K, Slavik J. On the minor alkaloids from *Argemone mexicana* L. *Collection of Czechoslovak Chemical Communications*. 1975;40(5):1576-8.
- [14] Brahmachari G, Gorai D, Roy R. *Argemone mexicana*: chemical and pharmacological aspects. *Revista Brasileira de Farmacognosia*. 2013 Jun;23(3):559-67.
- [15] Adam SI, Idris IA, Abdelgadir EH, Ahmed RH, Kamal EE. Evaluation of hepatoprotective activity of *Argemone mexicana* aerial Part Extracts on CCL₄ induced liver damage in wistar rats. *British Journal of Pharmacology and Toxicology*. 2011 Nov 25;2(5):251-6.
- [16] Sourabié TS, Kone HM, Nikiéma JB, Nacoulma OG, Guissou IP. Evaluation of the antihepatotoxic effect of *Argemone mexicana* leaf extracts against CCl₄-induced hepatic injury in rats. *International Journal of Biological and Chemical Sciences*. 2009;3(6).
- [17] Bapna S, Choudhary PK, Ramaiya M, Chowdhary A. Antiplasmodial activity of *Argemone mexicana*: an in vivo and in vitro study. *World J Pharm Res*. 2015 Sep 12;4:1653-63.
- [18] Sharma S, Sharma MC, Kohli DV. Pharmacological screening effect of ethanolic and methanolic extract of fruits of medicinally leaves. *Digest journal of nanomaterials and Biostructures*. 2010 Mar 1;5(1):229-32.
- [19] Sukumar D, Arivudai Nambi R, Sulochana N. *Studies on the leaves of Argemone mexicana*. *Fitoterapia*. 1984.
- [20] Dash GK, Murthy PN. Evaluation of *Argemone mexicana* Linn. Leaves for wound healing activity. *J Nat Prod Plant Resour*. 2011;1(1):46-56.
- [21] Ghosh T, Dash GK, Bose A, Panda BR. Wound healing properties of *Argemone mexicana*. *Indian J Nat Prod*. 2004;20(4).
- [22] Saranya M, Arun T, Iyappan P. In vitro antibacterial activity and preliminary phytochemical analysis of leaf extracts of *Argemone Mexicana* Linn—A medicinal plant. *Int J Curr Pharm Res*. 2012 May;4(3):85-7.
- [23] Singh SK, Pandey VD, Singh A, Singh C. Antibacterial activity of seed extracts of *Argemone mexicana* L. on some pathogenic bacterial strains. *African Journal of Biotechnology*. 2009;8(24).
- [24] Jain RA, Agarwal RC, Dubey D, Verma R, Jain R. Evaluation of antibacterial and antioxidant activity of fruits extract of *Argemone mexicana* Linn. *Int J Pharm innov*. 2012;2:45-51.
- [25] Rosas-Pinon Y, Mejia A, Diaz-Ruiz G, Aguilara MI, Sanchez Nietoc S, Rivero-Cruza JF 2012. Ethnobotanical survey and antibacterial activity of plants used in the altiplane region of Mexico for the treatment of oral cavity infections. *J Ethnopharmacol* 141: 860-865.
- [26] Alagesabooopathi C, Kalaiselvi N. Antimicrobial activities of the root, stem and leaf extracts of *Argemone mexicana* L. *Int J Biosci*. 2012;2:61-8.
- [27] Singh A, Singh S, Singh S, Singh TD, Singh VP, Pandey VB, Singh UP. Fungal spore germination inhibition by alkaloids dehydrocorydalmine and oxyberberine. *Journal of plant protection research*. 2009.
- [28] Bhalke RD, Gosavi SA. Anti-stress and antiallergic effect of *Argemone mexicana* stems in asthma. *Arch Pharm Sci Res*. 2009;1(2):127-9.
- [29] Chang YC, Chang FR, Khalil AT, Hsieh PW, Wu YC. Cytotoxic benzophenanthridine and benzyloquinoline alkaloids from *Argemone mexicana*. *Zeitschrift für Naturforschung C*. 2003 Aug 1;58(7-8):521-6.
- [30] Sakthivadivel M, Thilagavathy D. Larvicidal and chemosterilant activity of the acetone fraction of petroleum ether extract from *Argemone mexicana* L. seed. *Bioresource technology*. 2003 Sep 1;89(2):213-6.
- [31] Sakthivadivel M, Eapen A, Dash AP. Evaluation of toxicity of plant extracts against vector of lymphatic filariasis, *Culex quinquefasciatus*. *The Indian Journal of Medical Research*. 2012 Mar;135(3):397.
- [32] Jaliwala YA, Panda PK, Chourasia N, Bhatt NK, Pandit A, Mohanti PK. In vitro anthelmintic activity of aerial parts of *Argemone mexicana* Linn. *Journal of pharmacy research*. 2011 Sep;4(9):3173-4.

- [33] Majeed A, Taju G, Nathiga Nambi KS, Menaka H. Anthelmintic activity of Argemone mexicana leaves extract against *Pheretima prosthuma* and *Ascaridia galli*. *Res J Pharm Biol Chem Sci*. 2011;2:773-7.
- [34] Nayak P, Kar DM, Maharana L. Antidiabetic activity of aerial parts of Argemone mexicana Linn. in alloxan induced hyperglycaemic rats. *Pharmacologyonline1*. 2011;1:889-903.
- [35] Rout SP, Kar DM, Mandal PK. Hypoglycaemic activity of aerial parts of Argemone mexicana L. in experimental rat models. *Int J Pharm Pharmaceut Sci*. 2011;3:533-40.
- [36] Chang YC, Hsieh PW, Chang FR, Wu RR, Liaw CC, Lee KH, Wu YC. Two new protopines argemexicaines A and B and the anti-HIV alkaloid 6-acetyldihydrochelerythrine from formosan Argemone mexicana. *Planta medica*. 2003 Feb;69(02):148-52.
- [37] Verma SK, Dev G, Tyagi AK, Goomber S, Jain GV. Argemone mexicana poisoning: autopsy findings of two cases. *Forensic Science International*. 2001 Jan 1;115(1-2):135-41.
- [38] Dalvi RR. Sanguinarine: its potential, as a liver toxic alkaloid present in the seeds of Argemone mexicana. *Experientia*. 1985 Jan;41(1):77-8.
- [39] Alnadif AA, Mirghani ME, Hussein IH. Unconventional oilseeds and oil sources. Academic Press; 2017 Apr 14.
- [40] Gupta RK. Foodborne infectious diseases. In *Food Safety in the 21st Century* 2017 Jan 1 (pp. 13-28). Academic Press.

