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A COMPREHENSIVE REVIEW ON THE ANTIBACTERIAL POTENTIAL OF ARGEMONE MEXICANA AGAINST MYCOBACTERIUM LEPRAE

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ABSTRACT

Leprosy remains a persistent public health concern, highlighting the need for new bioactive compounds with therapeutic potential. *Argemone mexicana* L., traditionally used to treat various skin disorders, has attracted interest for its possible antileprotic activity. The plant contains alkaloids such as berberine, sanguinarine, and chelerythrine, which exhibit antimicrobial, anti-inflammatory, and antioxidant properties relevant to leprosy. Although ethnobotanical evidence supports its historical use in chronic skin conditions, scientific data directly addressing its effects on *Mycobacterium leprae* are still limited. This review summarizes current knowledge on the botany, phytochemistry, and pharmacological properties of *A. mexicana*, emphasizing its potential relevance in leprosy management and the need for further mechanistic, toxicological, and targeted antimycobacterial studies. Overall, the plant shows promising but understudied potential as a future candidate for antileprotic drug development.

KEYWORDS: *Argemone Mexicana*, Antileprotic activity, Phytochemistry, Ethnomedicine, Antimycobacterial, Leprosy (Hansen's disease)

INTRODUCTION

Argemone mexicana L., commonly known as the Mexican prickly poppy, belongs to the family Papaveraceae. It is an erect, spiny annual herb that grows up to 1.2 meters in height. The plant is characterized by its bright yellow flowers, prickly stems and leaves, and ovoid seed capsules. It is a resilient species that adapts to diverse ecological conditions and thrives in both cultivated and uncultivated lands. It grows optimally in light, sandy soils but can also survive in nutrient-deficient environments. The plant typically flourishes during the summer season and has been described traditionally as having bitter taste and diuretic properties.[1]

Globally, A. mexicana is distributed across Nepal, Bangladesh, Fiji, Mauritius, Mexico, and the Americas. Its widespread occurrence, often as a common weed, has facilitated its incorporation into multiple traditional medical systems. The plant has long been valued for its therapeutic properties and has been extensively used in ethnomedicine for the treatment of skin diseases, infections, and systemic ailments. Various plant parts including leaves, roots, seeds, and latex are employed in indigenous remedies. For instance, the seeds have sedative, purgative, and protein-dissolving properties, while the latex and leaf extracts are applied topically to manage wounds, ulcers, and dermatological conditions.[2] Ethnobotanical records from regions such as India, Africa, Latin America, and Mexico document its use in treating leprosy-like lesions, jaundice, warts, and even as an antidote for snake envenomation.

Leprosy, also referred to as Hansen's disease, is a chronic infectious condition caused by Mycobacterium leprae. It predominantly affects the skin, peripheral nerves, and mucosal surfaces of the upper respiratory tract. Although the introduction of multidrug therapy has significantly reduced the global prevalence of leprosy, treatment challenges remain. These include issues of drug resistance, incomplete patient adherence, and the complex immunological reactions that contribute to chronic inflammation and tissue damage in affected patients. As a result, there is a continued need to explore alternative or adjunctive therapeutic agents that are effective, safe, and accessible, particularly in resource-limited regions.[1-2]

Medicinal plants have historically served as critical sources for novel drug discovery, especially in areas where conventional therapies are limited or unavailable. Argemone mexicana has been highlighted for its broad pharmacological activities, including antimicrobial, anti-inflammatory, antioxidant, hepatoprotective, and anticancer effects. Phytochemical studies have revealed that the plant is rich in isoquinoline alkaloids, notably

berberine, sanguinarine, and chelerythrine. These compounds exhibit strong biological activities that are relevant to the management of infectious and inflammatory conditions. Alkaloids such as berberine and sanguinarine have been reported to interfere with microbial cell walls, disrupt nucleic acid synthesis, and modulate oxidative stress and inflammatory pathways. This chemical diversity positions A. mexicana as a promising candidate for further scientific investigation as an antileprotic agent.[2]

The therapeutic relevance of A. mexicana is further reinforced by its extensive documentation in traditional medical systems. In Ayurveda, the plant is considered anthelmintic, purgative, and diuretic and is used to treat inflammatory conditions, bilious fevers, skin diseases, and leprosy. In African traditional medicine, it is utilized for malaria and skin infections, while in Mexico, the seed extract is applied as an antidote to snake venom and for dermatological complaints. Modern pharmacological studies have confirmed some of these traditional claims, demonstrating antibacterial, antifungal, anti-inflammatory, and antioxidant activities. However, direct scientific evidence of its activity against Mycobacterium leprae remains limited due to the organism's unique growth requirements and the difficulty of conducting in vitro studies. Despite this limitation, preliminary evidence from related mycobacteria suggests that the bioactive alkaloids in A. mexicana may exhibit inhibitory effects and modulate immune responses relevant to leprosy pathology.[2-3]

Secondary metabolites in plants, such as alkaloids, flavonoids, and phenolic compounds, play a crucial role in their therapeutic potential. Unlike primary metabolites, which are directly involved in growth, development, and metabolism, secondary metabolites contribute indirectly by modulating enzymatic pathways, oxidative stress, and microbial defense mechanisms.[4] The diverse secondary metabolite profile of A. mexicana underpins its multifaceted pharmacological properties and provides a rationale for its investigation as a candidate for novel antileprotic drug development.[2],[5]

In summary, Argemone mexicana L. represents a biologically rich and ethnomedicinally significant plant with promising therapeutic potential against leprosy. Its traditional applications, phytochemical diversity, and pharmacological activities collectively justify a systematic scientific exploration of its antileprotic potential. This review aims to critically evaluate existing literature on the botany, ethnomedicinal uses, phytochemistry, and pharmacological properties of A. mexicana, highlighting the gaps in current knowledge and

outlining future directions for research, including mechanistic studies, toxicity evaluation, and targeted antimycobacterial testing.[1-5]

Plant Profile

Fig. 1. Argemone Mexicana Linn. Plant.

Argemone mexicana L., commonly referred to as the Mexican prickly poppy, is an erect, spiny annual herb belonging to the Papaveraceae family. The plant is distinguished by its bright yellow flowers, prickly stems, and lobed foliage, and can reach up to 1.2 meters in height. It is highly adaptable, capable of growing in diverse ecological conditions, including cultivated fields, wastelands, and degraded soils. The species prefers light, sandy soils but can also tolerate nutrient-deficient environments, making it widespread across tropical and subtropical regions. Traditionally, *A. mexicana* has been valued for its medicinal properties. Its bitter taste is associated with digestive and liver-stimulating effects, while its diuretic properties have been used to manage fluid retention and metabolic imbalances. Ethnomedical practices have employed the plant in the treatment of bilious fevers, inflammatory skin disorders, chronic wounds, and leprosy-like lesions. Various parts of the plant, including the seeds, leaves, latex, and roots, have been used in indigenous remedies to reduce inflammation, microbial infections, and skin lesions.[1],[6]

The plant's ecological resilience, widespread availability, and rich phytochemical composition including alkaloids, flavonoids, fatty acids, and sterols underscore its significance in both traditional medicine and modern pharmacological research. Its documented antimicrobial, anti-inflammatory, and antioxidant activities further support its potential as a source of bioactive compounds for therapeutic applications, particularly in dermatological and infectious diseases.[7]

Table No. 1: Taxonomical Classification.[6]

Taxonomic Rank	Classification
Kingdom	Plantae
Phylum	Spermatophyta
Class	Dicotyledonae
Order	Papaverales
Family	Papaveraceae
Genus	*Argemone*
Species	*Argemone mexicana* L.

Major Chemical Constituents of *Argemone mexicana* L.: The therapeutic potential of *Argemone mexicana* L. is largely attributed to its diverse and bioactive phytochemical composition. The plant contains a wide range of alkaloids, flavonoids, fatty acids, sterols, saponins, phenolic compounds, proteins, and amino acids. These constituents collectively contribute to its antimicrobial, anti-inflammatory, antioxidant, cytoprotective, and cardioprotective properties, making it a promising candidate for pharmacological exploration.[8]

Table No. 2: Major Chemical Constituents, Classes, and Pharmacological Activities.[7-8]

Compound	Class / Nature	Pharmacological Activity	Mechanism of Action /Biological Relevance
Sanguinarine	Benzophenanthridine Alkaloid	Antimicrobial, Anti-inflammatory, Anticancer	Inhibits microbial growth, modulates inflammatory pathways, induces apoptosis; toxic at high doses
Dihydro-sanguinarine	Alkaloid	Antimicrobial	Enhances antimicrobial efficacy and overall bioactivity; contributes to toxicity
Berberine	Isoquinoline Alkaloid	Antimicrobial, Antidiabetic, Anti-inflammatory	Inhibits microbial nucleic acid synthesis, modulates inflammatory mediators, regulates glucose metabolism
Protopine	Alkaloid	Sedative, Analgesic, Antispasmodic	Modulates nervous system signaling, reduces muscle spasms and pain
Chelerythrine	Benzophenanthridine Alkaloid	Antimicrobial, Anti-inflammatory, Anticancer	Protein kinase C inhibitor; modulates inflammatory pathways and induces apoptosis
Allocryptopine	Alkaloid	Antispasmodic, Anti-inflammatory	Reduces smooth muscle contractions, modulates inflammatory mediators
Argemonine	Alkaloid	Antimicrobial	Disrupts microbial cell membranes
Coptisine	Isoquinoline Alkaloid	Antimicrobial, Anti-inflammatory	Inhibits microbial growth, modulates cytokine production
Quercetin	Flavonoid	Antioxidant, Anti-inflammatory,	Scavenges free radicals, protects cellular membranes, inhibits

		Cardioprotective	inflammatory enzymes
Kaempferol	Flavonoid	Antioxidant, Anti-inflammatory, Anticancer	Reduces oxidative stress, modulates inflammatory pathways, induces apoptosis
Rutin	Flavonoid Glycoside	Antioxidant, Anti-inflammatory, Vascular protective	Stabilizes capillaries, scavenges free radicals, reduces inflammation
Ferulic Acid	Phenolic Acid	Antioxidant, Anti-inflammatory	Neutralizes free radicals, protects against oxidative stress
Sinapic Acid	Phenolic Acid	Antioxidant, Anti-inflammatory	Scavenges reactive oxygen species, modulates inflammatory mediators
Caffeic Acid	Phenolic Acid	Antioxidant, Anti-inflammatory, Antimicrobial	Reduces oxidative stress, inhibits microbial growth, modulates inflammation
Argemonoside	Saponin	Anti-inflammatory, Antimicrobial	Disrupts microbial cell membranes, modulates immune responses
Argemonesaponin	Saponin	Antimicrobial, Anti-inflammatory	Disrupts microbial cell walls, enhances immune defense
Palmitic Acid	Saturated Fatty Acid	Nutritional, Energy source	Contributes to lipid content, supports energy metabolism
Oleic Acid	Monounsaturated Fatty Acid	Cardioprotective, Anti-inflammatory	Modulates lipid metabolism, reduces inflammation
Linoleic Acid	Polyunsaturated Fatty Acid	Cell membrane integrity, Anti-inflammatory	Essential for membrane structure, supports immune function
β-Sitosterol	Phytosterol	Anti-inflammatory, Cholesterol-lowering, Immunomodulatory	Modulates inflammatory mediators, reduces cholesterol absorption
Proteins	Macromolecule	Nutritional, Pharmacological support	Contribute to metabolic functions; some proteins linked to toxicity
Amino Acids	Macromolecule	Nutritional, Pharmacological	Building blocks of proteins; involved in metabolic and enzymatic pathways
Phenolic Compounds	Polyphenols	Antioxidant, Antimicrobial	Scavenge free radicals, protect against oxidative stress, inhibit microbial growth

Botanical Description: *Argemone mexicana* L. is an annual herb characterized by a slightly branched taproot, allowing it to reach a height of up to 150 cm. The plant has multiple branched stems, which are densely covered with prickles, and exudes a yellow latex when cut. The leaves are alternate, sessile, and resemble thistles, with serrated margins. The upper leaf surface exhibits a bluish-green hue, contrasted by prominent grey-white veins. Morphologically, the stem cross-section is oblong, providing structural support for the spiny branches. The bright yellow flowers, measuring 2.5-5 cm in diameter, are positioned at the

terminal tips of the branches, facilitating pollination. Fruits are ovoid or oblong capsules, often prickly, containing nearly spherical, brownish-black seeds approximately 1 mm in diameter. Each seed is covered by a delicate network of veins, adding to the plant's distinctive morphology.[9]

Traditional Uses of A. Mexicana: *Argemone mexicana* L. has a long history of use in traditional healing practices across multiple continents, reflecting its extensive medicinal legacy. Various parts of the plant, including the roots, seeds, leaves, flowers, and yellow latex, have been utilized for centuries due to their potent therapeutic properties.[10] In Indian traditional medicine, latex and leaf extracts are commonly applied topically to manage dermatological conditions such as ringworm, eczema, scabies, ulcers, and non-healing wounds.[11] The milky sap has also been used to treat ocular conditions, including corneal opacities and conjunctivitis. The seeds possess sedative and laxative effects, supporting their use in alleviating gastrointestinal disorders, insomnia, and mild anxiety.[12] While high doses of seed oil are considered toxic, controlled administration is traditionally employed to relieve rheumatic pain and joint inflammation. In rural areas, especially northern India, burning or smoking the seeds is a popular home remedy for respiratory congestion and dental pain.

The plant has also been used to manage a variety of infectious and systemic diseases. Aerial parts, including leaves and stems, exhibit analgesic, antispasmodic, anti-parasitic, and anti-narcotic activities and have been traditionally employed to treat conditions such as icterus, dropsy, and malaria. Topical application of latex or fresh leaf juice is believed to disinfect wounds and cuts. Fresh milky seed extract is reported to be effective against leprosy, warts, cold sores, jaundice, malarial fever, skin lesions, scorpion stings, and inflammation, likely due to the presence of bioactive secondary metabolites, including protein-dissolving compounds.[10-12]

Pharmacological studies support some of these traditional claims. Extracts of the aerial parts of *A. mexicana* have demonstrated hypoglycemics activity in normal and experimentally induced diabetic rats, reducing blood glucose, triglycerides, and cholesterol in a dose-dependent manner. Additionally, strong anti-HIV activity has been observed in the benzophenanthridine alkaloid (±)-6-acetonyl dihydrochelerythrine, isolated from methanolic extracts of air-dried whole plants. The roots are traditionally used to manage constipation, flatulence, colic, vesicular calculi, guinea-worm infestation, menorrhagia, and various forms

of poisoning, as well as hepato-biliary disorders and vaginal discharges when administered as a maceration.[13]

Overall, the diverse ethnomedicinal applications of *A. mexicana* highlight its potential as a source of bioactive compounds for antimicrobial, anti-inflammatory, metabolic, and antiviral therapies, warranting further systematic pharmacological and toxicological investigations.

Table No. 3: Traditional Uses and Modes of Application of *Argemone mexicana* L.[13]

Plant Part	Traditional Use	Mode of Application
Leaves	Liver ailments, jaundice, gum infections, fever	Decoction, mouthwash, poultice
Flowers	Cough, asthma, bronchitis	Expectorant infusion
Seeds	Toothache, snakebite antidote, constipation, sedative	Smoke inhalation, oral administration
Root	Rabies, pain, eye disorders	Aqueous extract, juice
Latex	Skin infections, ulcers, leprosy, scorpion sting	Topical application
Whole Plant	Malarial infections, antibacterial, diuretic, purgative effects	Juice, decoction

USE OF ARGEMONE MEXICANA AS ANTI-LEPROTIC AGENT: *Argemone mexicana* has long been used in traditional medicine to treat skin infections and inflammatory conditions. Modern studies suggest that its extracts, rich in bioactive alkaloids like berberine and sanguinarine, show promising activity against *Mycobacterium leprae*. These compounds may inhibit bacterial growth by disrupting DNA replication and cell wall synthesis. Beyond its direct antibacterial effects, *A. mexicana* also possesses anti-inflammatory properties that could help alleviate tissue damage caused by leprosy. While preliminary evidence is encouraging, further research is needed to confirm its efficacy and safety in clinical settings.[14]

Medicinal importance of *A. mexicana* juice/latex: *Argemone mexicana* has a long history of traditional medicinal use. Its latex and fresh leaf juice are commonly applied topically to treat boils, cuts, open wounds, and scorpion stings, acting as natural disinfectants and wound dressings. The latex is also used for skin conditions, leprosy, blisters, indolent ulcers, and eye infections, while its application on the body helps relieve rheumatic pain. Additionally, the plant's extracts have been employed to manage dropsy, jaundice, inflammations, burning sensations, and malarial fever.[14-15]

Fig. 2. Argemone Mexicana Plant Latex.

Medicinal importance of A. Mexicana seed: The seeds and seed oil of *Argemone mexicana* possess significant medicinal properties. The seed oil is strongly purgative and has traditionally been used to treat various skin disorders. In Mexico, the seeds have been employed as an antidote for snake poisoning, while in India, the smoke from the seeds is used to relieve toothache. The fresh yellow, milky seed extract contains protein-dissolving compounds and demonstrates a broad spectrum of pharmacological activities, including diuretic, anti-inflammatory, anti-malarial, anti-leprotic, and wound-healing effects. It has also been used to manage scorpion stings, warts, cold sores, skin diseases, itching, jaundice, and as a general antidote for various poisons. The seeds are known for their demulcent, emetic, expectorant, and laxative properties. Small infusions can serve as a mild sedative for children, though caution is warranted due to the strongly purgative nature of the seed oil. Additionally, the seeds and their oil have been applied to treat dysentery, ulcers, asthma, and other intestinal disorders, while the plant's latex is traditionally used in the management of conjunctivitis. These diverse applications highlight the seeds' multifaceted therapeutic potential and reinforce the ethnomedicinal significance of *A. mexicana*.[16-17]

LEPROSY: AN OVERVIEW AND ITS THERAPEUTIC CHALLENGES: Leprosy, or Hansen's disease, is a chronic infectious disorder caused by *Mycobacterium leprae* that primarily affects the skin and peripheral nerves, though it can also involve the eyes, mucous membranes, bones, and testes. The infection often leads to nerve damage, resulting in loss of sensation, deformities in hands and feet, blindness, and facial disfigurement, which contribute to long-term disability in millions of individuals worldwide. While multidrug therapy (MDT) effectively targets the mycobacterial infection, managing the nerve damage and its complications remains a significant clinical challenge.[18] *M. leprae* preferentially infects macrophages, Schwann cells, and keratinocytes, and the host immune response including the

release of antimicrobial peptides such as defensin plays a crucial role in controlling bacterial proliferation. Global initiatives, such as the 1991 World Health Assembly goal to "eliminate leprosy as a public health problem," have successfully reduced prevalence, but the disease persists in several regions, emphasizing the need for sustained management and long-term care strategies. Given these challenges, exploring complementary approaches, including traditional medicinal plants with antimicrobial and anti-inflammatory properties, has gained increasing attention. One such promising candidate is *Argemone mexicana*, which has been reported to exhibit potential anti-leprotic activity and could support conventional therapy in managing this complex disease.[19]

Epidemiology of Leprosy: Leprosy continues to be a public health concern in several regions worldwide, despite significant progress in disease control. The highest burden is observed in South Asia, Southeast Asia, Africa, and South America, with India, Brazil, and Indonesia reporting the largest numbers of new cases each year. Globally, over 200,000 new cases are detected annually, disproportionately affecting marginalized communities with limited access to healthcare. Transmission occurs primarily through prolonged close contact via respiratory droplets, although the exact mechanisms are not fully understood. Children are particularly susceptible, and cases in young populations indicate ongoing transmission. Risk factors include poor socioeconomic conditions, overcrowding, malnutrition, and genetic predisposition. The long incubation period of *Mycobacterium leprae*, often ranging from 2 to 10 years, delays diagnosis and treatment, increasing the risk of nerve damage and deformities. While multidrug therapy (MDT) has significantly reduced prevalence and prevented disability, localized endemicity persists, highlighting the need for continued surveillance, early intervention, and complementary therapeutic approaches, including exploration of traditional medicinal plants such as *Argemone mexicana*.[20]

Microbiology of Leprosy: *Mycobacterium leprae*, the causative agent of leprosy, is an obligate intracellular, acid-fast bacillus belonging to the genus *Mycobacterium*. The bacterium is rod-shaped, measuring approximately 0.3–0.5 µm in width and 1–8 µm in length, and is distinguished by a thick, lipid-rich cell wall containing mycolic acids. This unique cell wall confers resistance to desiccation, certain disinfectants, and many antimicrobial agents, contributing to its persistence within host tissues. *M. leprae* stains strongly with Ziehl-Neelsen acid-fast staining due to its high lipid content. Unlike most bacteria, it cannot be cultured on artificial media, which limits laboratory studies and

necessitates the use of animal models, such as the nine-banded armadillo and mouse footpad, for research purposes.[21]

The bacterium exhibits a strong tropism for Schwann cells in peripheral nerves and macrophages in the skin, which underlies the characteristic nerve damage and dermatological manifestations of leprosy. It's extremely slow doubling time of approximately 12–14 days accounts for the long incubation period of the disease, typically ranging from 2 to 10 years. The structural and physiological characteristics of *M. leprae* not only explain the chronic nature of leprosy but also pose challenges for treatment and drug development, emphasizing the need for adjunctive therapeutic approaches, including exploration of plant-based antimicrobials like *Argemone mexicana*.[22]

Table No. 4: Morphology and Characteristics of *Mycobacterium leprae*.[22-23]

Sr. No.	Feature	Description
1	Shape	Slender, slightly curved rod-shaped bacillus
2	Size	1–8 µm in length and 0.3–0.5 µm in diameter
3	Staining Properties	Acid-fast (weakly acid-fast); Gram-positive by traditional staining, though difficult to visualize due to the waxy cell wall
4	Cell Wall	Waxy coating rich in mycolic acids, rendering it impermeable to routine stains
5	Mobility	Non-motile
6	Spore Formation	Non-spore-forming
7	Metabolism	Microaerophilic (requires low oxygen concentration)

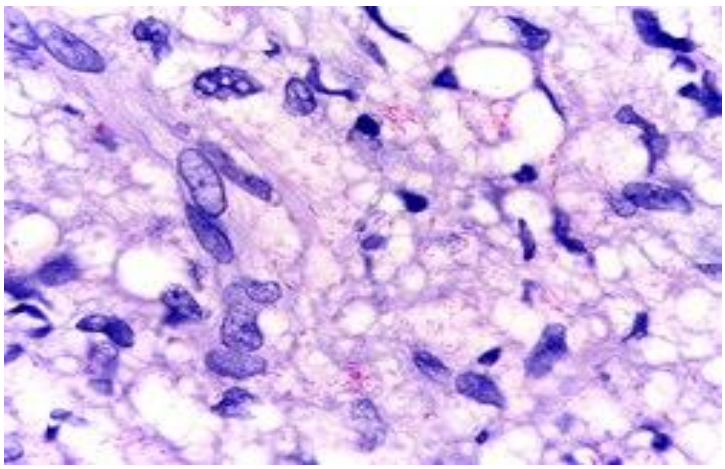

Fig. 3. Microbiology of Bacteria.

Fig. 4. ***Mycobacterium Leprae.***

Modes Of Transmission: Leprosy is primarily transmitted through prolonged close contact with untreated patients, particularly within families or households. The bacilli may also be present in the environment, and indirect contact with contaminated soil has been suggested as a potential, though less common, route. Droplet infection is considered the main pathway, as *Mycobacterium leprae* can be spread via sneezing or coughing from infected individuals. Other possible modes include mother-to-child transmission through breast milk, bites from insects such as fleas or bedbugs, and contaminated instruments, including tattoo needles. The incubation period of leprosy is typically 3-5 years, though in some cases it may be longer, contributing to delayed diagnosis and disease progression.[24]

Symptoms of Leprosy

Leprosy manifests primarily in the skin, peripheral nerves, and eyes, with additional systemic effects in advanced cases:

Skin

1. Light or reddish patches with reduced or absent sensation to touch, heat, or pain
2. Thickened, dry, or scaly skin
3. Painless ulcers, particularly on the feet
4. Loss of eyebrows or eyelashes in advanced cases

Peripheral Nerves

1. Numbness or tingling in hands, arms, feet, or legs
2. Muscle weakness, such as difficulty holding objects or walking
3. Enlarged peripheral nerves, often near elbows, knees, or sides of the neck

Eyes

1. Dryness and reduced blinking
2. Vision problems, which may lead to blindness if untreated

Other Symptoms

1. Nasal congestion or nosebleeds
2. Deformities of hands and feet in advanced cases due to nerve damage

Understanding the transmission routes, incubation period, and clinical manifestations of leprosy is crucial for early detection, disease management, and the development of complementary therapeutic strategies, including the potential use of traditional medicinal plants like *Argemone mexicana*.[25]

Classification Of Leprosy

Leprosy is classified based on clinical presentation, bacterial load, and immune response of the host. Accurate classification is important for diagnosis, treatment planning, and predicting disease progression. The commonly used classifications include.[26]

1. Ridley-Jopling Classification

This system categorizes leprosy into five types based on clinical, histopathological, and immunological features:

1. Tuberculoid (TT)

1. Strong cell-mediated immunity.
2. Few, well-demarcated hypopigmented skin lesions with significant nerve involvement.
3. Low bacterial load (paucibacillary).

2. Borderline Tuberculoid (BT)

1. Features intermediate between tuberculoid and borderline forms.
2. Multiple lesions with asymmetrical nerve involvement.

3. Mid-Borderline (BB)

1. Unstable form between tuberculoid and lepromatous types.
2. Moderate bacterial load with symmetric skin lesions.

4. Borderline Lepromatous (BL)

1. Weaker immunity than BB, higher bacterial load.

2. Numerous lesions, often symmetrical; nerve involvement may be less severe initially.

5. Lepromatous (LL)

1. Poor cell-mediated immunity.
2. Diffuse skin lesions, nodules, plaques, and widespread nerve involvement.
3. High bacterial load (multibacillary).[27]

2. WHO Classification

The World Health Organization (WHO) uses a simplified classification for treatment purposes

1. Paucibacillary (PB)

1. Fewer than 5 skin lesions.
2. Low bacterial load; suitable for shorter multidrug therapy (MDT).

2. Multibacillary (MB)

1. More than 5 skin lesions or positive slit-skin smear.
2. High bacterial load; rquires longer MDT.

This classification system not only guides therapeutic decisions but also helps in epidemiological surveillance and monitoring treatment outcomes.[28]

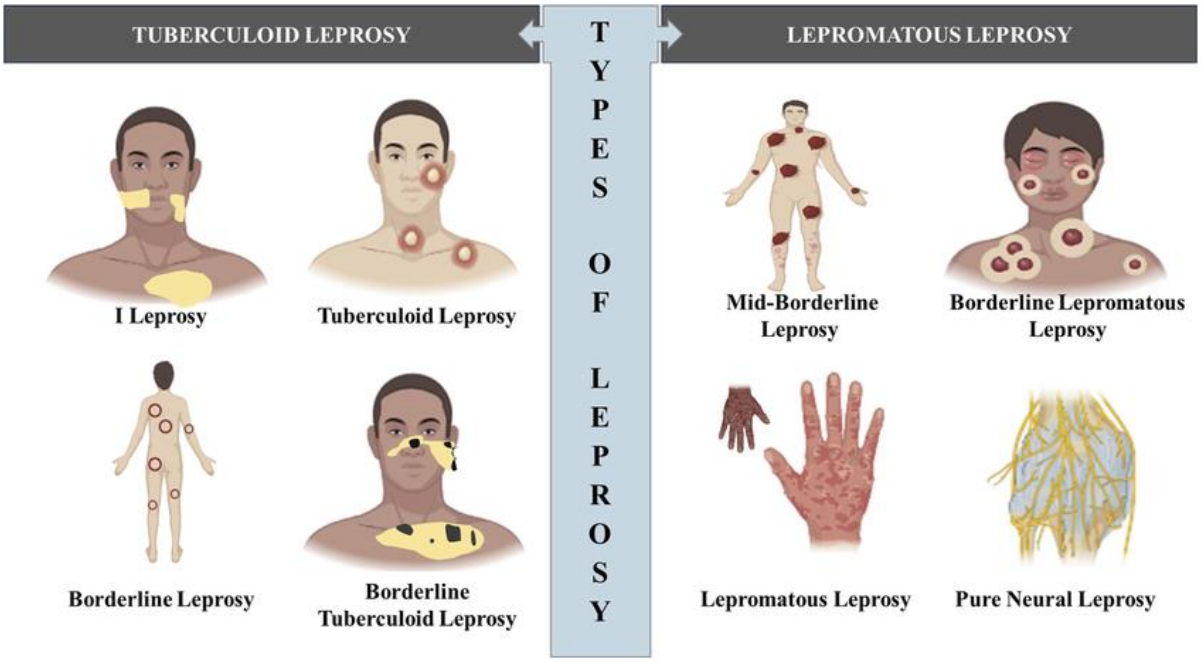

Fig. 5 Types of Leprosy.

CONCLUSION

Argemone mexicana L. harbors bioactive alkaloids with antimicrobial, anti-inflammatory, and antioxidant properties, suggesting potential relevance in leprosy management. Despite supportive ethnobotanical evidence, direct studies on its activity against *Mycobacterium leprae* are limited. Further mechanistic, toxicological, and targeted antimycobacterial research is needed to validate its therapeutic potential and guide the development of novel plant-based antileprotic agents.

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