REVIEW ARTICLE

A Review on Pharmaceutical Potential of *Parthenium* Plant

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Abstract

Parthenium plant, in general, is known to be harmful, dangerous, and invasive in nature. It causes much economic loss to farmers by affecting the cultivation of crops and considered to be a threat to primary production of crops and biodiversity as well. *Parthenium hysterophorus* a weed belonging to the family Asteraceae, it is an erect short-lived plant and is known for its fleshy growth along sides of abandoned places, roadsides, and uncultivated lands. This weed is found in hot and humid climates around the globe. This invasive species is known with different names in different countries such as carrot weed, star weed, congress grass, wild feverfew, ragweed, bitter weed, and white top. The spread of *P. hysterophorus* has been found to cause enormous loss to biodiversity by replacing natural ecosystems and sometimes known to cause total habit alternation. In this review article, we discuss *P. hysterophorus* as a weed, its origin, reproductive bionomics, chemical composition, and its pharmaceutical potential as antibacterial, anti-inflammatory, hypoglycemic, anti-HIV, and antitumor activity in detail.

Key words: Antibacterial, Antifungal, melatonin, parthenin, *Parthenium hysterophorus,* pharmaceutical activities

INTRODUCTION

Parthenium species is a highly toxic and threateningly invasive weed found in more than 30 countries.[1] This plant causes a lot of threat to crops, livestock, and mankind.[2] This weed is a perennial herbaceous weed that invades isolated lands, disintegrates ecosystems and can cause rigorous allergic reactions to animals, and it triggers significant problems in forestry, crops, and rangelands. This invasiveness is caused due to several biological and ecological conditions of the weed plant.[3] This plant, in the field of agriculture, reduces the crop production rigorously, which in turn brings great loss in farming, live stocks and thereby causes huge economic loss to humans.[4] There were a lot of approaches that have been made for destruction, management and to control the outbreak of the plant, such as burning, chemical herbicides, and use of eucalyptus oil and biological control measures such as feeding the leaves to beetles. *Parthenium* species has also been proved to have many health benefits such as remedy for skin inflammation, diarrhea, neuralgia, and malaria[5] and also commercial value and industrial usage[6] such as removal of metal, eradication of aquatic weeds, cattle manure for biodiesel production, and biopesticide production.[7]

This herb is known for its vigorous growth and high fertility[8] in all climatic conditions, especially warmer climates.[9] It causes ecological and agricultural losses every year on a large scale and is considered as one of the worst weeds for its invasiveness and environmental aspects. It has a negative impact on the beef industry, costing a loss to farmers in Queensland over 100 million Australian dollars per year due to reduced production.[10] Many people, when exposed to the plant and its pollen, get severe allergic reactions. If cattle consume a large quantity of this weed its affects the quality of the milk, i.e., the milk gives a bitter taste on consuming. This weed was introduced into India in 1950 as contaminants of PL480, which is a type of wheat seed and these *Parthenium* seeds, which resembles as PL480 seeds were imported from the USA.[11]

Origins and spread

Parthenium weed is native to the Gulf of Mexico, including the South United States of America, and is possibly native

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to northern Argentina, South Bolivia, and Southwest Brazil and Australia.[12] India has become one of the most affected countries with this notorious weed, which is occurring in all of its states and becoming a major problem in uncultivated lands. Herbarium records show that at least one *Parthenium* species existed in the 1800s, and *Parthenium* weed has now spread from India into most of its neighboring countries. It is believed that this spread has occurred by vehicles or as a contaminant of agricultural seeds to Katmandu, Bhutan, Bangladesh, and Pakistan and probably taken also to Sri Lanka with goats accompanying an Indian military mission. Another severely affected region is in East Africa, with Ethiopia and Nepal.[13] A rural location just North of Brisbane has a widespread effect on the land for a couple of decades.

Ecology, anatomy, and reproductive bionomics

Parthenium weed is an annual (under certain conditions) perennial with an erect and much-branched growth habit. Fully grown plants can reach a height of 2.5 m, though most individuals do not exceed 1.5 m. The leaves are pubescent and strongly dissected into lobes. The white cluster of flowers (4 mm across) has 5–7 distinct ray florets and grows on the stem tip. A typical flower produced four or five blackish achiness enclosed in a fruit layer, which is brownish in color with two lateral attached sterile florets. The rapid germination and fast growth rate and allelopathic nature of this plant help it to suppress nearby vegetation and allow it to grow vigorously and, as a result, produced a large number of seeds that increase the size of its soil utilization/occupancy.[14] This notorious weed commonly germinates in the spring and develops flowers and seeds throughout its lifetime and perishes only in late autumn. It starts flowering when the plant is just 1 year old and will flower up to 6–8 months, respectively.[15] This weed can germinate, flower, and grow in hot temperate conditions; hence, it can be seen developing at any time of the year. However, the primary season for growth is summer, when there is a plentiful amount of rain and the aerial parts of the plant do not tolerate extreme cold conditions. This weed is mostly found in areas that are not farmed and are of low fertile properties such as wastelands and roadsides, river beds, and plant nurseries[13]

Seed developments and impact on humankind

Under appropriate conditions, these plants produce flowers just after 22–48 days of germination. Williams and Grooves found that the best alternating temperature period for seed germination was 22–27°C. While some studies show that the best temperature for these weeds to germinate would be 16–25°C and also analyzed that, under farm conditions, this particular seed must be buried 5 cm below ground and the plants would survive for about a period of 2 years, with partial life expectancy of 7 years.[16]

Direct and indirect effects on food and beef production are due to this weed can invade and destruct certain plants such as *Oryza sativa, Triticum aestivum* (wheat)*, Zea mays* (maize), and *Sorghum* in different regions of the globe. *Parthenium* weed is symbolized for its impact on decreased production as much as 40% in India and by 28% in Ethiopia. The crop production has been depleted due to this notorious weed and is a critical threat to Ethiopian food management as it confers a significant impact on the production of food and fodder. Contamination of rice and wheat varieties with sustainable species has severe consequences for the export and import of crop products. On a local scale, contamination with the weed can affect the marketing of dairy-related products. It is also reported to act as a carrier for various plant pathogens *Xanthomonas campestris, Hairy caterpillar* (*Diacrisia obliqua* walk virus), and streak virus.[4] *Parthenium* plant parts are toxic to animals. About 73% of people living along the weed are said to be affected. *Parthenium hysterophorus* causes dermatitis due to the exposure of the key phytochemical Parthenin.[17]

CONTROL OF *PARTHENIUM*

The control of *Parthenium* weed is a great challenge due to its rapid spreading nature. Measures have to be improvised to eradicate this plant since it has more impact on biodiversity and mankind. India has a great risk of rapid spread in agricultural fields. Active research is going on to find a cost-effective method and effective way to control this weed.[18] The followings are some of the control measures followed and its effectiveness toward *Parthenium* eradication.

Overgrazing control

In many cases to control plant growth grazing and overgrazing are allowed. However, in the case of *Parthenium*, on overgrazing in certain places increase relatively. Overgrazing, due to the high increase in live stocks decreases the vigor and diversity of grassland that makes the spread of the weed even more lavishly. Hence, maintenance of correct livestock numbers may prevent the spread of *Parthenium*.[19]

Control by burning

The most widely practiced way to control *Parthenium* weed is to burn it. Huge vegetation of this weed can be effectively destroyed in this manner. However, this is not a safe control method as there is a great threat to soil water and fertility of biodiversity. The ash of *Parthenium* has an allelopathic effect on certain plants but the loss of yield is low in comparison to the dry mass of this weed.[20]

Herbicide control

Herbicidal control is the most effective and widely used method to control *Parthenium* weed. However, the current

efficacy of bioherbicides is not as effective as chemical herbicides till date. Chemical herbicides are commonly called glycerophosphate, bromoxynil, NaCl, amine, esters, fluometuron, hexazinone, metribuzin, norflurazon, and paraquat. The above herbicides are effective in the control of *Parthenium*.[21,22] This weed can be controlled using chemical herbicides in non-cropping areas as well as cropping areas. Cropping areas are a bit risky to practice these herbicides as they damage primary crops. Chemical fertilizer used in agricultural farms needs certain precautions to choose the herbicides so that it cannot harm crops. On the other hand, biological and natural herbicides such as oils from medicinal plants in low concentrations are effective and helpful in the control of *Parthenium*.[23] These oils have no or little effect on the current crops as much as on *Parthenium*.[24]

Biological control

Biological control has been proven to be the best method to control the spread of *Parthenium*. This can be done by feeding the plants to insects, and we can also use fungi, bacteria, and other plants that have adverse effects on this weed. The moth *Epiblema strenuana* from Mexico is predominant in *Parthenium* existing places. The larvae of the moth feed on the stem of *Parthenium* and inhibit plant growth considerably, acting as a biological control agent.[25]

PHYTOCHEMICAL COMPOSITION OF *PARTHENIUM*

Maishi *et al*. (1998) have found out that all parts of the invasive weed *Parthenium* including trichomes show characteristic compounds and toxins, as mentioned in Table 1. More than 16 phytochemicals have been reported in various literatures to be isolated and identified from *Parthenium* plants. The majority of these molecules belong to the classes of phytosterols, terpenes, and flavonoids.

Flavonoid content

Multiple qualitative and quantitative phytochemical screenings have been reported for *Parthenium*. In comparison, a large quantity of flavonoid content has been reported in *P. hysterophorus* leaf, stem, flower, and root in different extracts of the same. The different concentrations of flavonoid content in different parts of the plant and in different extracts are summarized in Table 2.[26]

PHARMACEUTICAL POTENTIAL OF *PARTHENIUM*

Being known as an invasive weed plant, *Parthenium* has also been known for its pharmaceutical activities such as antimicrobial, anti-inflammatory, sleeping aid, antidiabetic, antiviral, and antitumor. The following sections cover the pharmaceutical value and physiochemical properties that can change the approach of this plant from an unwanted weed to a useful phytochemical source.

Antimicrobial activity

Crude extracts of *P. hysterophorus* leaves, stem, and root were tested and proven to possess antibacterial activity against Gram-positive bacteria *Streptococcus mutans* and Gram-negative bacteria *Salmonella typhi*.[27] Leaf extracts such as chloroform, hexane, and benzene extracts showed inhibition of both the bacterial strains at 2 mg/disc. However, the inhibitory factor of hexane and benzene was more dominant.[27] Ethanolic extract of the leaves showed moderate antibacterial activity.[28] Root extracts of *P. hysterophorus* showed a significant amount of antibacterial activity against *S. mutants,* while the extracts exhibited low to negligible antibacterial activity against *S. typhi*. Kumar *et al*. (2013) investigated seven different solvent extracts such as hexane, benzene, chloroform, ethyl alcohol, acetone, ethanol, and water of three different parts of the plant, i.e., leaf, stem, and root for their antimicrobial activity. Among these benzene extract of leaf showed maximum activity ranging from 16 mm to 12 mm and benzene root extract showing 16 mm of antibacterial activity against the test pathogens.[29] The benzene extract of the herb powder shows significant antibacterial activity against test pathogens, in comparison to the other polar solvents such as acetone, water[30] Several studies on *P. hysterophorus* confirm that it exhibits strong antimicrobial and fungal activity. *P. hysterophorus* inhibits the growth of rhizobium, acetobacter, rhizosphere, as well as it can inhibit *Fusarium oxysporum*, *Candida albicans*, *Staphylococcus aureus*, *Escherichia coli*, etc.[31]

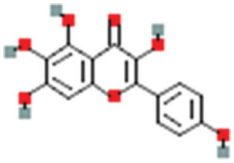
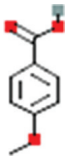
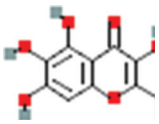
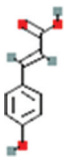
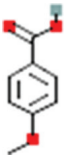
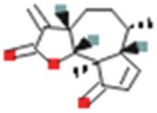
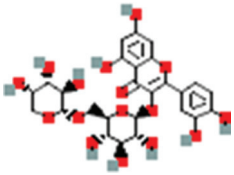
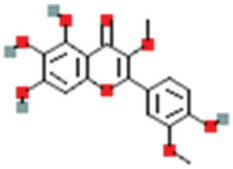
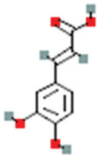
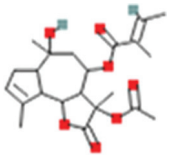
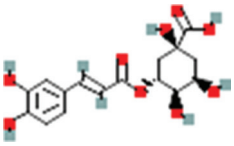
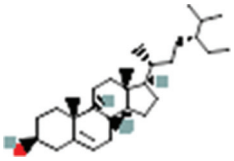
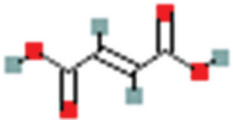
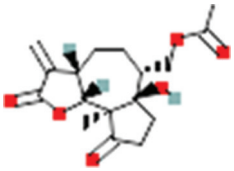
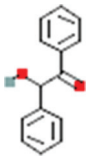
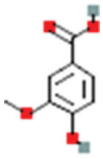
Anti-inflammatory activity

Inflammation is a term used to define the process of biological response to harmful stimuli such as pathogens, allergens, or it can be an immunological response.[32] Jain and Kulkarni reports that oral consumption of *Tanacetum parthenium* treated with acetic acid inhibited writhing in mice model caused by carrageenan-induced paw edema.[33] These actions and responses were dose reliable (10, 20, 30, and 40 mg/kg) and on the further study on fewer few parthenolide doses (40–60 mg/kg) confirmed that these neither altered the locomotor activity nor stopped the induced sleep time in mice. It also showed null fluctuations in the body temperatures of the rats, and it did not change the normal life cycle of the mice.[34] These studies report the anti-inflammatory potential of the plant.

Hypoglycemic effects

Type-2 diabetes is a serious disorder that alternates blood sugar levels on a serious note. Nearly 15% of the world

Table 1: Phytochemicals reported from *Parthenium*

Chemicals	Molecular weight (g/mol)	Chemical structure	Chemicals	Molecular weight (g/mol)	Chemical structure
6- hydroxyl kaempferol	302.23		p-anisic acid	152.15	
Ambrosin	246.3		P-coumaric acid	164.16	
Anisic acid	152.15		Parthenin	262.3	
Arabinoglucoside	596.5		Quercetagetin 3,4-dimethylether	346.3	
Caffeic acid	180.16		Sesquiterpene lactone LS-1	406.5	
Chlorogenic acid	354.31		Sitosterol	414.7	
Fumaric acid	116.07		Tetraneurin A	322.4	
Hydroxy benzoin	212.24		Vanillic acid	168.15	

population suffers from this disorder and is caused by a deficiency in insulin secretion by pancreatic glands. It is observed that when an aqueous extract of *T. parthenium* was administered to alloxan-induced diabetic rat models, the majority of the rats survived without side effects or mortality. The blood sugar level significantly reduced ($P < 0.01$) below 240 mg/dl in 2 h and when different set of rats treated with glibenclamide showed that the blood sugar level reduced up to 30% in the normal rat on comparison showed that the levels fell to 10% in 2 h of time while it was only 7% in the rats injected with *P. hysterophorus*. However, the reduction is less when compared to glibenclamide treated group. The

effect of aqueous extract of *P. hysterophorus* on blood sugar level is shown in Table 3.

Anti-HIV activity

Kumar *et al*. (2013) studied that the leaf extract of the *P. hysterophorus* for antiretroviral activity targeting HIV reverse transcriptase enzyme. The investigation was carried out using HIV reverse transcriptase inhibition kit, which estimated the effectiveness at two different concentrations (0.6 and 6.0 µg/ml). The extracts displayed low to moderate inhibition potential (<50%), suggesting that on purification and further studies, the active molecule responsible for inhibition of the reverse transcriptase could be identified.[35]

Tumor activity

Tumors are swelling of part of a body, generally without inflammation, caused by abnormal growth of tissue whether benign or malignant. A study by Mukherjee and Chatterjee (1993) showed that methanolic flower extract of *P. hysterophorus* showed antitumor activity in mice diseased with transplanted lymphocytic leukemia.[36]

Sleeping aid

Melatonin is a hormone that regulates the sleep-wake routine in mammals and other animals are often used as a treatment for insomnia.[37] Melatonin has recently been identified in some plant cells/tissues and has been used traditionally as a sleep substituent. Ansari *et al*. reported that indoleamine is known for its alternation and regulation of circadian cycles.[38] Many reports in the past have found out that melatonin is present in plant extracts. This indirectly paves the way for good antioxidant activity as well.[37]

Parthenium has been reported to contain melatonin in alcoholic extracts. Using chromatographic studies such as high-performance liquid chromatography and selective confirmation techniques such as enzyme-linked immunosorbent assay, it was confirmed that *Parthenium* plant extracts contain significant amount of melatonin and that this plant has the potential to be used as sleeping aid.[39]

Other uses of *Parthenium*

As larvicide

Larvicides are the chemical or biological agents that act as insecticide, particularly to the larval life stage of an insect. *P. hysterophorus* acts as a brilliant larvicide. Investigations on *Parthenium* showed that its larvicidal properties can be used to control larvae of different mosquitoes and aphids that harm human health and crops, respectively. Larvicidal potency of *Parthenium* extracts against *Aedes aegypti* larvae, and other larvae were reported to be significant.[31] The leaf extract of this weed showed notable downfall in reproductive capacity and reduction in lifetime of *Lipaphis erysimi*.[40] The use of modern chemical pesticides or insecticides has proven to be harmful to plants and humans who consume it on a daily basis. *Parthenium* being a biological substituent, acts as an ideal biological source for larvicidal applications.[7]

As compost

P. hysterophorus is known to be a wonderful source of micro- and macro-molecules and acts as a good compost for farmlands.[41] Due to the abundance of these macro- and micro-nutrients in the

Table 2: Flavonoid content in *P. hysterophorus* extracts

Extracts	Leaf (µg QE/mg)	Stem (µg QE/mg)	Flower (µg QE/mg)	Root (µg QE/mg)
Hexane	10.93±0.35	11.13±0.15	13.90±0.03	6.42±0.05
Benzene	7.60±0.15	14.31±0.22	15.01±0.08	4.99±0.09
Chloroform	14.55±0.16	5.42±4.62	36.29±0.17	7.36±0.11
Ethyl alcohol	10.83±0.25	4.62±0.13	59.62±0.14	2.95±0.13
Acetone	10.05±0.18	3.38±0.18	41.41±0.14	4.58±0.18
Ethanol	6.66±0.20	16.55±0.21	27.43±0.10	1.98±0.01
Water	2.64±0.20	2.58±0.09	20.25±0.12	1.88±0.02

P. hysterophorus: Parthenium hysterophorus

Table 3: Effect of *P. hysterophorus* aqueous extract on blood sugar level

Condition	Tween 80	Glibenclamide	*P. hysterophorus*
Pre-treatment	79.25±0.35	79.58±0.37	80.02±0.49
Post-treatment	79.58±0.37	71.22±0.70	74.98±0.49
% decrease	2.76	10.50	6.29

P. hysterophorus: Parthenium hysterophorus

plant, it can be utilized to grow plants more healthily. However, the high phenolics and oil content in this plant which shows a certain amount of allelopathic impact on growth, yield, and reproduction capacity of crop plants. Hence the plant cannot be used directly, rather can be recycled/decomposed and then used as nutrient for crops. Although this can be used as biofertilizer and compost, it relatively shows a good amount of activity on *Eichhornia crassipes*. Studies showed that *Parthenium* with *Eichhornia* decreases the harmful content of *Parthenium* and exhibits high nutritional value.[42]

As heavy metal and dye removal

Parthenium weed can be used in the extraction of heavy metals. *Parthenium* treated with HCl has been investigated for removal of certain chemicals such as nickel and dye absorbing efficiency from industrial wastes. Although it is dependent on the pH, its dye absorbing capability can replace commercially available products. Heavy metals that can experimentally be absorbed by *Parthenium* are nickel, cadmium, copper, and zinc, etc. Activated carbon prepared from *Parthenium* showed a phenol derivative cresol, which is high efficiency than the actual activated carbon.[4] As heavy metals dyes are known to possess carcinogenic properties, they are harmful to the environment and should be removed using biological sources such as *Parthenium* plants, which provides a unparalleled application of this unwanted weed plant.[42]

CONCLUSION

Parthenium species are considered to be waste/unwanted weeds that are generally burned or killed to increase the growth of primary crops. Considering the biological activity of this unwanted plant in the fields of antibacterial, antidiabetic, anti-inflammatory, and its other significant pharmaceutical and industrial applications, it can be converted into an economically valuable plant. These plants are normally killed or burned or destroyed; instead, these could be used as a source of valuable chemical and biological agents, to benefit the economy. Further studies in demand for confirmation of the concept, however, in a world trying to attain a sustainable economy, it would be best to exploit all natural sources to their best quality, even if the source is a weed such as *Parthenium*.

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CONFLICTS OF INTEREST

The authors confirm that there are no conflicts of interest for this review article.

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