

Pharmacological Activities of Miraculous Plant *Plantago Major* L.: A Review

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ABSTRACT

*There are various terms for medicine: aromatherapy, homeopathy, flora-therapy, alternative medicine and herbal medicine. Among them herbal medicine is the back bone of traditional medicine in many countries and played important role in curing human diseases since prehistoric time. Medicinal plants are rich source of biologically active compounds that have disease preventive properties. The present review collects information on traditional uses and pharmacological activities of *Plantago major*. It has many medicinal properties such as immune modulating property, antiviral, anticarcinogenic, antidiabetic, antioxidant, anti-inflammatory, analgesic activity and other. Such medicinal properties of *P. major* is due to the presence of biologically active chemical compounds such as polysaccharides, lipids, caffeic acid derivatives, flavonoids, iridoid glycosides, terpenoids, alkaloids and some organic acids. There is need for detail investigation of these bioactive compounds of *P. major* which are responsible for its medicinal properties and their effects at molecular level. Moreover, pharmacological properties of biologically active compounds in *P. major* are required to corroborate the claimed folkloric information of *Plantain*.*

Keywords: Medicine, herbal medicine, *Plantago major*, pharmacological activities, bioactive compounds

Introduction:

In the developing countries, a major population live in poverty as a result they suffer and struggle for need of food, pure water, clothing, shelter, medicine and education. Among them, medicine is of paramount importance and without this human being cannot achieve the other needs. Therefore, there is further need to search for medicinal plants with the objective of validating their traditional medicinal use and their extraction, isolation and identification of compounds, which may be added to the potential list of drugs.

The nature has provided a complete storehouse of remedies to cure ailments. The knowledge of plants and its benefits accumulated over thousands of years of human beings intrusive nature and today we possess many effective means of health care. For thousands of years, people around the world have used herbs and plants to cure or prevent diseases. The humans are more afflicted to diseases than any other animal species. From ancient time the medicines used, were from the plants and it can be said that plant is men's only chemist for ages. In modern time, a vast store of knowledge and research concerning therapeutic properties of different plants has accumulated [1].

India has rich heritage of traditional medicine and healthcare system that is flourishing from many centuries [2]. There are various terms for medicine: aromatherapy, homeopathy, flora-therapy, alternative medicine and herbal medicine. Among them herbal

medicine is most important. Herbs are an important part of nature containing naturally occurring substances that can treat and prevent diseases and promote good health. The natural products especially derived from plant sources are gaining much attention for therapeutic use than that of conventional ones. Because conventional medicines shows unwanted side effects but natural product shows negligible side effects. Herbal industries are receiving greater attention worldwide since the innumerable potential compounds from plant products serve as starting points for the development of new drugs.

The WHO is playing a leadership role in encouraging the development of scientific approaches for the evaluation and utilization of traditional medicines where among the total of 252 drugs in WHO's essential medicine list, 11% is exclusively of plant origin [3]. It is observed that though great advances have been made in modern medicine in recent decades, plants still make an important contribution to health care. Much interest, in medicinal plants however, emanates from their long use in folk medicines as well as their disease preventing properties, especially in developing countries. Plants are utilized as medicines for thousands of years [4]. These medicines initially took the form of crude drugs such as tinctures, teas, poultices, powders and other herbal formulations. In recent history, the use of plants as medicines has involved the isolation of active compounds, beginning with the isolation of morphine from opium in the early 19th century [4];[5]. The plants have several medicinal properties that can be obtained from the different parts of the plant such as leaves, roots, bark, fruit, seeds, flowers etc. The different parts of plants can contain different active ingredients within one plant. Phytochemicals are naturally occurring, biologically active, non-nutritive plant chemicals that have natural defence system or disease preventive properties. The plants produce phytochemicals that provide colour, aroma and flavour, thus inviting attention from potential consumers.

Phytochemicals are non-essential nutrients, it means that they are not required by the human body for sustaining life. It is well known that plant produce these chemicals to protect themselves, but recent research demonstrates that they can also protect humans against diseases. There are more than thousand known phytochemicals such as lycopene, isoflavones and flavanoids in tomatoes, soybean and fruits. The other secondary metabolites are namely polyphenols, glycosides, flavonoids, terpenoids, phenolic acids, steroids, fatty acid derivatives, polyketides, alkaloids etc. The aim of this review article is to deepen the knowledge of pharmacological activities of miraculous plant *P. major*.

2. PLANT PROFILE:

Plantago major is an old medicinal plant known for centuries [6];[7]. *Plantago major* belongs to the genus *Plantago* family Plantaginaceae. Being common it has many English names as broad-leaved plantain (has the broad leaves), dooryard plantain, Englishman's foot, greater plantain, healing blade, road weed, snakeweed and white man's footprint. This plant is native of Europe, but is also found in some parts of northern and central Asia and has widely naturalised all over the world. *P. major* was discovered about 4000 years ago in Europe and later it spread from Europe throughout the world. They are very common and can be found in meadows, fields, wastelands, on roadsides and in ditches.

Plantago major L. is a small perennial plant with height about 15 cm, but the size varies depending on the growth habitats. The leaves grow in rosettes and may ovate to elliptical with parallel venation. The leaves are glabrous and have an entire or irregularly dentate margin. The flowers are small, brownish-green and with long non-ramified spikes. The seeds of this herb are quite small with an ovate shape and have a slightly bitter taste [6]. In general, people call it as weed [8].

Taxonomic Position

Kingdom	-	Plantae
Division	-	Magnoliophyta
Class	-	Magnoliopsida
Order	-	Plantaginales (Lamiales)
Family	-	Plantaginaceae
Genus	-	Plantago L.
Species	-	<i>Plantago major</i>
Binomial name	-	<i>Plantago major</i> L.

Vernacular names

Hindi	-	Lahuriya
Sanskrit	-	Asvagola
Tamil	-	Ishappukol vitai



Figure 1 *Plantago major* (Greater plantain or Broad leaf plantain) and its parts

Chemical Constituents

The chemical composition of a plant and possible synergy of its constituents, impart therapeutic potential to a plant or plant products. However, genomic composition, developmental stage and ambient environmental conditions often cause spatio-temporal variation in the chemical profile of plants, as well as harvesting techniques, post-harvest processing, storage conditions, widespread use of pesticides, frequent adulteration and microbial contamination are notable causes in variations of chemical profile of medicinal plant.

The genus *Plantago* (Plantaginaceae) comprises 265 species with a worldwide distribution [6]. Phytochemical investigation of the genus revealed the presence of iridoid glycosides, phenylpropanoid glycosides, flavonoids and phenylcarboxylic acids. The iridoid glucosides aucubin and catalpol, as well as phenylpropanoid glycoside acteoside, are the main constituents of *Plantago* species [9].

Plantago major is rich in secondary metabolites. Since long time the *Plantago* species is being used as medicine in herbal formulations. *Plantago major* contains biologically active fractions such as polysaccharides, lipids, caffeic acid derivatives, flavonoids, other phenolic compounds, iridoid glucosides

(glycosides), terpenoids, alkaloids and some organic acids such as oleanolic acid and ursolic acid [10];[6].

In recent years, a considerable number of different iridoids have been isolated from the genus *Plantago* and these include aucubin and compounds biosynthetically related [11]. It is highly nutritious edible herb rich in calcium and vitamins A, C, and K also.

Traditional Uses:

Plantago major L. has been used as traditional herbal medicine for centuries all over the world. Several studies have shown *Plantago major* as plant with medicinal properties involving the use of plant extracts and its isolated natural fractions [12] and found effective to cure chronic constipation, digestive disorders, diarrhea, piles and alleviated problems of kidney, bladder and hemorrhoids. Traditionally, *P. major* is taken in various forms as herbal tea, in salads, as a vegetable, as well as mixed in with other ingredients to make soups or baked goods. Different parts of *P. major* such as leaves, stem, root, seeds etc. are known to possess therapeutic potential and have been used traditionally for the treatment of various ailments. The poultices of the *P. major* leaves is applied to wounds, stings, sores to prevent infection due to its wound healing properties and its seeds are used to treat various gastrointestinal disorders, kidney problems, piles and asthma. Plantain roots are used to treat fever, constipation, anti-venom for snake bites and respiratory infections. Recent scientific studies show that *P. major* have wound healing, anti-inflammatory, analgesic, antioxidant, weak antibiotic and antiulcerogenic, antileukemic and antihypertensive activity effects [10];[6], anti-colon cancer, antibacterial, immunomodulatory, proliferative, antimutagenic [13].

5. PHARMACOLOGICAL ACTIVITIES OF PLANTAGO MAJOR:

Plants have a great potential of producing new drugs for human benefit. The increased interest in plant derived drugs is mainly because of the wide spread belief that 'herbal medicine' is safer than synthetic drugs having no side effects. *P. major* is well-known traditional herbal plant to treat various diseases [8]. In addition the traditional uses of *P. major* some researchers also prove its medicinal properties. The therapeutic potential of *Plantago major* has been discussed under the following headings:

Wound Healing Activity:

Plantago major has been used as a wound healing medicine in different parts of the world for centuries. The whole or crushed leaves of plantain are directly applied on wounds of all types, burns and wasp stings. Clinically confirmed an aqueous extract of *P. major* leaves at a dose of 5 to 10 % in vaseline shows significant wound healing activity [14]. In another study, the wound healing activity of ethanol and aqueous greenhouse-grown and freeze-dried leaves extracts of *plantago major* were evaluated by *ex-vivo* porcine wound healing model. Both extracts promoted wound healing in porcine skin, but the ethanolic extract was more effect in wound healing. 1.0 mg/ml (on dry weight basis) concentration of both the extracts showed the paramount activity [15].

Anti-inflammatory and Analgesic Activities:

Inflammation is an important physiological reaction, which occurs in response to injury of cells and body tissues through different factors such as infections, chemicals, thermal and mechanical injuries by limiting damage and promoting tissue repair [16]. It is noted that excessive inflammation leads to rheumatoid arthritis, psoriasis and other inflammatory diseases [17]. The five basic symptoms of inflammation are

redness, swelling, heat, pain and deranged function known since the ancient times. The drugs used in the treatment of inflammation are nonsteroidal anti-inflammatory drugs (NSAIDs) and steroidal anti-inflammatory drugs (SAIDs). These drugs have toxic effects such as ulceration and bleeding, renal damage, hypertension, hyperglycemia [18]. Therefore, continuous research is been done to reduce such side effects. Whereas, medicinal plants are known as alternate and important natural source of chemical substances with potential therapeutic effects as pain relievers and anti-inflammatory agents with less side effects.

In this study the aqueous extract of *P. major* leaves at a dose of 1g/kg shows significant reduce in paw edema and pleurisy induced by carrageenin in rats. The results shows that aqueous extract of *P. major* have anti-inflammatory and analgesic activities [19]. In the other study, the methanolic extract of *Plantago major* seeds was investigated for anti-inflammatory activity against carrageenan induced paw oedema in rats. The findings of this study showed that *P. major* methanolic seeds extract have significant anti-inflammatory activity [20].

Anti-ulcerogenic activity:

Ulcers are an open wound of the skin or mucus membrane and characterised by an external loss of tissue. Many types of ulcers are known such as mouth ulcer, esophagus ulcer, peptic ulcer and genital ulcer. Among these peptic ulcer is most common in many people [21]. Several medicinal plants and herbs are used to treat various gastrointestinal problems in traditional medicinal system. The *Plantago major* is one such plant traditionally used for treatment of various gastrointestinal diseases. The methanol extract and infusions of *Plantago major* were tested for antiulcerogenic activity against 0.6 N HCl, 0.2 N NaOH, 2.5% NaCl and ethanol induced gastric ulcers in rats. The result shows that methanol extract and infusions possess significant antiulcerogenic activity [22]. In another study Methanol extracts of *P. major* leaves and seeds were prepared and evaluated for their antiulcerogenic effect using ethanol and aspirin induced gastric ulcer in rats. The methanol extract at a dose of 400mg/kg body weight, p. o., was selected for this study. The findings of this study suggested that the *P. major* leaves produced a potent antiulcerogenic effect against ethanol and aspirin induced gastric ulcer in rats [23]. Yesilada *et al.* reported that *Plantago major* aqueous extract was given orally showed significant antiulcerogenic activity by using water immersion-stress ulcer model in rats [24]. Phipps and Mahmood, also reported that aqueous extract of *Plantago major* leaf is a most potent to control the ulcer formation induced by ethanol [25].

Hypoglycemic activity:

In one study conducted by Jin and Noor the hypoglycemic activity of four different doses 100, 200, 400, 600 mg/kg body weight per oral of aqueous extract of *Plantago major* leaf was studied. The results showed that only aqueous extract of *Plantago major* leaf at a dose of 600 mg/kg shows significant decrease in glucose level in diabetic rats. The hypoglycemic effect of the aqueous extract was less when compared to the standard hypoglycemic drug, glibenclamide (10mg/kg) [26]. In another study 70% ethanol extract was also tested for hypoglycemic activity in normoglycemic rats. The study concluded that ethanol extract was found potent to reduce blood glucose level [27].

Antiviral activity:

In this study the aqueous extract and pure compounds of *P. major* were tested for antiviral activity against different viruses, namely herpes viruses (HSV-1, HSV-2) and adenoviruses (ADV-3, ADV-8, ADV-11). The results showed that the aqueous extract possessed only weak anti-herpes viral activity on the other hand pure compounds of *P. major* extract showed significant antiviral activity. The findings of this study suggested that the pure compounds of *P. major* which exhibited potent antiviral activity belong to phenolic compounds. The study concluded that pure compounds of *P. major* can be used for treatment of the infections caused by herpes and adenoviruses [28].

Immunomodulatory activity:

Plantago major and its parts have been possessed different medicinal properties such as anti-inflammatory, antibacterial, antiviral, antitumor and wound healing activity, which supported the immune boosting property. In this study, hot water extracts of *Plantago major* L. and *Plantago asiatica* L. were evaluated for the antiviral, cytotoxic and immunomodulatory activities against a series of viruses, such as herpes viruses (HSV-1, HSV-2) and adenoviruses (ADV-3, ADV-8, ADV-11) and on different human leukemia, lymphoma and carcinoma cells with XTT, Brb U and interferon gamma (IFN- γ) kits. The results showed that the hot water extract possessed significant antileukemia, anticarcinoma, antiviral and immunomodulatory activities [10].

In another study, endotoxin-free methanol extract of *plantago major* leaves, at doses of 50, 100, 250 and 500 $\mu\text{g/ml}$, were examined for immunoenhancing properties. The results showed that *Plantago major* possessed immunomodulatory activity [29]. Some studies reviewed that *Plantago major* possessed immunostimulatory effect by enhancing lymphocyte proliferation and secretion of interferon-gamma [30];[31].

Anti-diarrheal activity:

In the present times gastrointestinal disorders is gaining a universal problem. Diarrhea and dysentery are severely affecting the human population. In the developing countries the infants mortality is related to the diarrhea. In India many medicinal plants are used as traditional folklore medicine for the treatment of diarrhea [32]. Diarrhea is related to viral or bacterial infection and food poisoning. In this study, seven medicinal plants were collected from Egypt, *Plantago major* was one of them. The methanolic extract of *P. major* leaves was tested for anti-diarrheal activity against castor oil-induced diarrhea in rats. The findings of this study suggested that methanolic extract at a dose of 200 and 400mg/kg possessed significant anti-diarrheal activity against castor oil induced diarrhea [33].

Anticancer activity:

Some studies reviewed that the *P. major* leaf extracts have been used for treatment of skin cancer [6]. Kobeasy *et al.* reported that ethanolic, hot and cold water extracts of *Plantago major* leaves and seeds evaluated for anticancer activity by the MTT assay. The findings of this study suggested that ethanolic extracts of *P. major* leaves and seed exhibited greatest anticancer activity than the hot and cold water extracts. This study concluded that ethanolic extract of *P. major* leaves had the highest effect on tumor cell growth followed by hot water and cold water extract of *P. major* leaves followed by ethanol extract, hot and cold water extracts of *P. major* seeds [34]. In one study, Gomez-Flores *et al.* studied that *Plantago major* leaf extracts increase nitric oxide and TNF- α production of macrophages-mediated lymphocyte proliferation. Macrophages play an important role in altering immunity. The results of this

study concluded that *P. major* strengthen the immune system which may be clinically related in various diseases such as chronic viral infections, tuberculosis, AIDS and cancer [30]. In another study, investigated by Galvez *et al.* the methanolic extract of seven plantago species used in traditional medicine system for cancer treatment, were tested for cytotoxic activity against three human cancer cell lines recommended by the National Cancer Institute, USA. The findings of this study showed that methanolic extract of *Plantago* species revealed cytotoxic activity due to the presence of flavonoids in tested species because flavonoids are capable to inhibit the proliferation of human cancer cell lines [35]. One study also reported that the hot water extract of *Plantago major* leaves was investigated for antitumor activity in Ehrlich ascites tumor (EAT) bearing Balb/ C mice *in vivo*. For this study different concentration (1%, 2% and 3%, 0.1 ml/day/mouse) of *P. major* extract were given orally for ten alternate days. The findings of this study showed that different concentration of hot water extract of *P. major* leaves has inhibitive effect on EAT [36].

Antioxidant activity:

Oxidative stress is one of the main causes of chronic and degenerative diseases [37]. Antioxidant substances possess the ability to protect the body from free radical damages caused by free radical-induced oxidative stress. A number of medicinal plants are promising source of natural antioxidants [38]. The several review of studies indicated that *P. major* is a rich source of phytoconstituents which shows its medicinal properties including antioxidant activity. In this study, the different extracts (petroleum ether, ethyl acetate and aqueous fractions) of *P. major* were evaluated for antioxidant activity by DPPH free radical scavenging, β -carotene bleaching assay and ferrous ion chelating activity method. The findings of this study suggested that ethyl acetate fraction exhibited the highest radical scavenging power and relative antioxidant activity in the β -carotene bleaching assay but petroleum ether and aqueous fractions showed lower antioxidant activity. Among all the fractions, the aqueous fraction has a capacity of chelating iron [39]. Another study conducted by Reina *et al.* concluded that ethanol extract of *Plantago major* and its two bioactive compounds baicalein and aucubin significantly reduced the production of reactive oxygen species by human neutrophils [7].

It is reported in some studies that the natural products possessing antioxidant property shows liver protective activity against acetaminophen (APAP). One of the studies investigated the effect of *P. major* methanolic leaves extract on the liver injury caused by acetaminophen (1000mg/kg., p. o) toxicity on male rats. This study concluded that the liver protective effect of *P. major* methanolic extract is by boosting the activities of innate antioxidants [40]. In another study, the whole parts of five medicinal plants including *P. major* were collected from Iran. The methanolic extracts of these plants evaluated for total phenol contents, flavonoid contents and radical scavenging activity. This study suggested that *P. major* extract showed DPPH free radical scavenging activity which was comparable to standard antioxidant molecule BHT that is due to the presence of high amount of phenolic compounds in the plant extract [41]. Kobeasy *et al.* reported that the ethanolic, hot and cold water extracts of *P. major* leaves and seeds showed that leaves extract exhibited higher antioxidant activity than the seed extracts. Among all the extracts, the ethanolic extract of *P. major* leaves possessed highest free radical scavenging activity [34]. It was reported by Souri *et al.* [38]; Beara *et al.* [42] that phenolic compounds have been the main bioactive compounds responsible for antioxidant activity of methanol extract of *P. major*. One study concluded that the methanolic extract of aerial parts of *P. major* subsp. *intermedia* exhibited antioxidant activity which can be related to the presence of the phenylpropanoid glycoside, isomartynoside [43]. Miser-Salihoglu *et al.* investigated different solvent leaves extracts of *Plantago lanceolata* L., *Plantago*

major L. ssp. *major*, *Rubus hirtus* Waldst & Kit., *Sambucus ebulus* L., *Morus alba* L. and *Hedera helix* L., for total phenolic compounds and *in-vitro* antioxidant activity. The results of the study showed that *P. lanceolata*, *R. hirtus*, *S. ebulus* and *P. major* L. ssp. *major* had similarities in terms of phenolic compounds content however *M. alba* and *H. helix* were found to have relatively low content of phenolic compounds. Therefore, *Plantago* species exhibited high antioxidant activities [44]. In another study, Ren *et al.* observed that the high altitude had different effect on antioxidant activity of leaves and roots extracts of *Plantago major* [45].

Hepatoprotective activity:

Liver is the major site of intensive metabolic activity. Liver dysfunction because of toxic chemicals, certain drugs and environmental pollutants has been largely increased in the last few decades. Herbal treatment of many diseases including hepatopathy is increasing in many countries. According to this study the *P. major* methanol seed extract was examined for hepatoprotective activity against carbon tetrachloride (CCl₄) induced hepatotoxicity in male and female Sprague Dawley rats for seven days. The three different doses selected for this study were 10, 20, and 25 mg/kg respectively. The seeds extract showed significant hepatoprotective activity against CCl₄ induced change in biochemical parameters and histopathological findings that was confirmed by enzymatic examinations. The hepatoprotective activity of *P. major* seed extract was comparable with the standard silybinin [20]. In another study the methanolic extract of *P. major* leaves was tested for liver injury against acetaminophen toxicity in male Sprague Dawley rats. Test groups received low and high dose of *P. major* methanolic leaves extract 1000mg/kg and 1500mg/kg respectively. The plant extract showed significant liver protective activity against acetaminophen induced change in biochemical parameters. The liver protective activity of *P. major* extracts was comparable with the standard N- acetylcysteine. The plant extract may hamper the formation of free radicals, which may conclude in liver protective activity [40]. Najmi *et al.* studied a poly herbal formulation jigrine, containing aqueous extracts of 14 medicinal plants including *Plantago major*. The poly herbal formulation was tested for hepatoprotective activity against galactosamine induced hepatopathy in rats. The results of this study showed significant liver protective activity of jigrine against galactosamine [46].

Antimalarial activity:

Malaria is one of the life-threatening diseases caused by protozoans that are transmitted to people through the bites of infected female Anopheles mosquitoes. One study evaluated the anti-malarial activity against Plasmodium falciparum chloroquine sensitive 3D7 strain using ethanol extracts of 10 different medicinal plants. These plants were selected on the basis of their primitive traditional knowledge and *Plantago major* was one of the selected plants that showed promising anti-malarial activity (IC₅₀ 40.00 µg/ml) [47].

Antimicrobial Activity:

Different extracts (Petroleum ether, ethyl acetate and aqueous fractions) of *Plantago major* leaves were studied for antibacterial activity by using disc diffusion method. Gentamicin was used as standard antibiotic. According to the results, the ethyl acetate fraction was most potent against Gram negative and Gram positive bacterial strains. Highest inhibition zone was exhibited on *Staphylococcus aureus* (16.7±1 mm) and *Bacillus cereus* 14.3±0.6mm. Moderate inhibition zone of 13.3±0.6 and 11.3±0.6 mm was obtained against *Pseudomonas aeruginosa* and *Acinetobacter bowie* and lowest activity was obtained

against *Klebsiella pneumonia*, *Proteus mirabilis* and *Salmonella typhimurium*. Also synergistic antibacterial activity was either obtained by the combination of standard antibiotic with the tested extracts. Therefore, it is suggested that the *P. major* leaves extract can be potent antibacterial agent [39]. In another study, the antibacterial activity of methanolic leaves extract of *Ceratonia siliqua* and *Plantago major* with different concentrations were evaluated by Agar well diffusion method. Six bacteria strains *Lactobacillus sp.*, *Staphylococcus aureus*, *Proteus sp*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Enterococcus sp.* were selected for the study. The both plant extracts had antibacterial activity but methanolic extract of *Plantago major* was better than the *Ceratonia siliqua* against the six types of bacteria strains [48]. The other study also confirmed the antimicrobial activity of the ethanolic extracts of *P. major* against some gram-negative (*Escherichia coli*, *Pseudomonas aeruginosa*) and gram positive (*Staphylococcus aureus*, *Bacillus subtilis*) bacteria as well as yeast-like fungi (*Candida albicans*, *Candida galabrata*, *Candida krusei*) by the agar diffusion method. The ethanol extract showed higher activity against *E. coli* and *S. aureus* [49].

Antidiabetic activity:

Diabetes mellitus is nowadays becoming a common disease because of stress and easy life style. It is considered as metabolic disorder characterized by hyperglycaemia that result from defects in insulin secretion and action or both. In this study, the methanolic extract of *Plantago major* leaves was tested for antidiabetic effect. Diabetes was induced by streptozotocin in Wistar rats. The methanolic extracts were administered orally at a dose of 100 and 200mg/kg for 15 days. The finding shows that methanolic extract (200mg/kg) of *Plantago major* leaves confirmed antidiabetic activity [50]. One study reported that *Plantago major* is been used in Malaysia as a traditional medicine for treatment of diabetes and other ailments. The alcoholic extract of *Plantago major* leaves was evaluated for antidiabetic activity against streptozotocin (STZ) - induced male Sprague Dawley diabetic rats. The oral glucose tolerance test (OGTT) was selected for the study. Alcoholic extract was given orally for 14 days at a dose of 500 and 1000mg/kg/day respectively. The findings of this study suggested that the 1000mg/kg dose of alcoholic extract showed significant antidiabetic activity in streptozotocin induced rat model [51].

Anti-fatigue effects:

Fatigue is a state of exhaustion as a result of excessive mental or physical exertion. The ethanolic extract of *Plantago major* seeds was evaluated for endurance exercise capacity in mice. Three different doses (0, 60 and 120 mg/kg) of ethanolic seed extract were selected for the study. The study confirmed that ethanolic seed extract of *Plantago major* possessed anti-fatigue effects and enhanced endurance exercise capacity [52]. There is less recorded study available on this effect hence there is scope of further research on this effect.

Conclusion

From, this review article, it is concluded that *Plantago major* is one of the important medicinal herb that have many pharmacological activities. The scientific research on this plant suggests it is a rich source of phytochemicals which supports its huge biological potential making it as a well known medicinal herb. Considering the miraculous medicinal properties of *P. major* it can be concluded that it is a traditionally and clinically proven medicinal herb known for its application and efficacy among human.

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