Review Article

Comprehensive Review on the Pharmacology, Phytochemistry, and Ethnobotany of *Fumaria indica* (Fumitory) Plant

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Abstract: *Fumaria indica*, popularly referred to as "Fumitory" or Pugsley, is a widely used cannabis variety in Pakistan and India. Due to its numerous anthelmintic, diuretic, diaphoretic, laxative, stomachic, and sedative qualities, it is frequently utilised in traditional and folkloric medical systems. In ethnopharmacology, the plant also alleviates liver blockage and purifies blood. In the systems of Ayurveda and Unani medicine, it has medicinal properties. The main emphasis of this review is the isolation of different phytochemical components from *Fumaria indica*, which exhibit significant pharmacological effects, including antibacterial, muscle-smoothing, relaxant, analgesic, and anti-inflammatory therapeutic activities. The hepatoprotective and antifungal properties of *Fumaria indica* are also highlighted in the review. Knowledge of the plant's conventional, ethnobotanical, phytochemical, and pharmacological characteristics is provided in the review; this knowledge may be helpful in molecular and cellular studies to further understand the mechanisms of action and potential therapeutic applications of *Fumaria indica*.

Keywords: Pharmacology; Fumaria indica; Pharmacopeia; Muscle relaxant; Gastro-protective.

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1. Introduction

A few of the many species on Earth have evolved adaptive traits to live in extreme environments with harsh abiotic conditions (Wang et al., 2023). Adaptation is the core of Darwin's evolution, and species need to adapt to the changing environment through Natural selection (Lai et al., 2019). Adaptation is the foundation of evolutionary biology and the protection of biodiversity is crucial (Rudman et al., 2022). Different regions have different spatial environments, and populations in different spatial environments need to adapt to the local biological and abiotic environments, therefore, improving the adaptation of different spatial environments is particularly important in population reproduction (Savolainen et al., 2013). Environmental variation leads to correlated variations in average population traits, as over evolutionary time, natural selection may be conducive to the occurrence of different phenotypes by acting on the heritable variation in the population (Botero et al., 2015; Franch et al., 2018; Tufto, 2015), and also affect the biological Reaction rate of organisms, thus generating biological adaptation at all levels of biological tissues (Rodriguez et al., 2017). Adaptive matching of organisms in specific environments can improve their reproductive success rate and survival rate. Organisms that do not match environmental conditions usually have to pay a certain price. For example, birds that breed under unstable food conditions have poor growth and reproduction of their offspring (McKinnon et al., 2012; Reed et al., 2013). In research on *Tamiasciurus hudsonicus*, it was found that females who gave birth to larger offspring in years with relatively low spruce cone production reduced the likelihood of mismatch errors in years with higher spruce cone production. However, their offspring grew slowly and rarely survived the first winter, making them unable to contribute to population reproduction (Petrulo et al., 2023).

Hengduan Mountains is the widest and longest north-south mountain system in China. Different habitats in different regions of the Hengduan Mountains usually have different environmental conditions, with specific geological and geographical driving factors, combined with human influence and interaction of abiotic and biological factors, which is a hot spot in the present study of animal adaptation strategies (Zhang et al., 2019). *E. miletus* is a special species of Hengduanshan Mountain, and produces complex and diverse distribution patterns, which provides us with excellent materials for studying animal adaptation strategies (Musthafa et al., 2021). *E. miletus* is widely distributed in Hengduan Mountains. The adaptation of *E. miletus* distributed in different regions of Hengduan Mountains to these climates may play an important role in forming genetic and phenotypic variations among populations (Hancock et al., 2008; Rodriguez et al., 2017). Therefore, in the face of this environmental fluctuation, *E. miletus* distributed in Hengduan Mountains may have different local adaptation patterns.

In the present study, we selected the adaptive changes in genes of *E. miletus* in Ailao Mountains (ALS, low altitude) and Deqin (DQ, high altitude), and these differences may involve changes in many traits of *E. miletus*. Previous studies have shown that the energy metabolism and skull geometry of *E. miletus* from different parts of the Hengduan Mountains have diverged markedly, and that the phenotypic and genetic changes show adaptations to diverse environments, which are related to environmental factors such as latitude, altitude, and mean annual air temperature (Zhang et al., 2019; Ren et al., 2023). Therefore, on the basis of previous studies, this study speculated that there should be regional differences in the reproductive adaptation strategies of *E. miletus* at different altitudes. Through simplified genome sequencing of *E. miletus* in ALS and DQ, analysis and reproduction related differential genes and differential gene expression measurement, and then reveal the local adaptation of *E. miletus* to environmental differences in reproduction. *Fumaria* species, also known as "fumitory," "earth smoke," and several other names, are commonly found in annual weeds (Ghadam et al., 2011). These plants have a broad geographic range, including countries such as India, Pakistan, Afghanistan, Iran, Turkey, Central Asia, and certain states in the U.S. states like Colorado and North Dakota (Gupta et al., 2012). A specific species, *Fumaria indica* (Haussk) Pugsley, recognized by other names like *F. parviflora* and *F. vaillantii,* is popular in both Ayurvedic and Unani medicinal systems (Orhan et al., 2010).In Ayurveda, this plant is known as 'Pitpapra,' and in Unani, it's referred to as 'Shahtra.' Recent studies and translations of ancient Sanskrit documents have recognized Several ancient texts, including Charak Samhita, Dhanvantari Nighantu, and Bhava Prakash, describe fumaria as an Ayurvedic herb.

Fumaria indica is used to treat a number of diseases in Ayurveda, including: Kaphaja and Pittaja Jwara (fevers with Kapha and Pitta origins), Daha (burning sensation), Arochaka (anorexia and disinterest in food), Chardi (vomiting), Pipasa (intense thirst), Mada (intoxication), Bhramai (dizziness and psychosis), Raktapitta (bleeding issues including nasal bleeding, Ulcerative colitis, and menorrhagia), and Glani (fatigue and sensory weakness). The plant's red blooms are employed for Atisara (diarrhea and dysentery).

Traditionally, the Indian Fumitory is used for various ailments like aches, pains, diarrhea, fever, influenza, and problems with the liver. Vomiting can be avoided by combining the plant and honey.Moreover, Children's wasting disorders, fever, constipation, and dyspepsia are all treated with a cold infusion of the herb. Applied externally for leukoderma and swollen joints, it is also known to purify blood and heal skin disorders.The dried herb is used as an anthelmintic, diuretic, and diaphoretic. It can also be used for jaundice when combined with black pepper(Shinwari et al., 2015).

Recent studies have corroborated the diverse medicinal benefits of this plant, pointing to its potential for further research. By investigating the correlations between its traditional uses and pharmacological properties, there is an opportunity to discover new drugs and formulations.

2. Geographical Distribution

Fumaria, a genus of plants found in Asia, Europe, and Africa, is known for its medicinal properties and traditional medicine. However, the plant in India, known as "*Shahtrah*" or "*Pitpapra,*" has been incorrectly identified as *Fumaria officinalis*, a European fumitory species not present in India(Khan et al., 2014). Identifying Fumaria species is challenging due to inter-specific hybridization, and fresh material is best for accurate identification. Fumaria species are found in India, Pakistan, Afghanistan, and Central Asia and have been introduced elsewhere. The misidentification of the plant in India as *Fumaria officinalis* underscores the need for proper botanical research and accurate identification of plant species. Further studies on Fumaria species' distribution and genetic diversity can provide valuable insights into their evolutionary history and conservation strategies(Keshavarzi et al., 2011).

3. Botanical description

F. indica is an annual herb with a pale green, much-branched appearance, growing up to 61 cm tall. Its leaves are multifid and glaucous, with 2-4 pinnatisect leaflets. The flowers are dense and hold 10–12 rose-coloured petals, with lanceolate-subulate bracts and short pedicels. The flowers are hermaphroditic, having a tubular shape with five sepals and five petals. They are typically pink or purple, although they can be white. The fruit is a cylindrical legume with several seeds(Modi et al., 2014). The sepals are green, and the petals are typically pink or purple, although they can also be white. The flowers have numerous stamens and a single pistil, which is characteristic of the Fabaceae family. This botanical description provides important information about *F. indica*.

The sepals are lanceolate or ovate, about 1.5 mm long, with an acuminate tip and slightly inciso-dentate edges. They are often persistent on the young fruit. The corolla is rose-coloured and measures around 5–6 mm in length. The fruit is subrotund, quadrate, and sometimes slightly retuse, with a width of about 2.5 mm. The light green stem is smooth on the exterior and hollow within, about 3–4 mm thick, while the branches are cylindrical and 2-3 mm thick, with a brown-coloured root 5, 9, 10). The brown-coloured root provides stability and nutrient absorption for the plant. Additionally, the light green stem allows for efficient transport of water and nutrients throughout the plant(Shinwari et al., 2015).

The leaf's morphology reveals a compound, pinnatifid shape with a linear to oblong shape and an anomocytic stomata arrangement. It has scattered sclerenchymatous bundles, thin-walled parenchymatous cells, and radiating medullary rays. Physicochemical studies reveal extractives soluble in alcohol, water, loss during drying, total ash, and foreign matter. The leaf contains carbohydrates, sugar, and tannins, suggesting potential medicinal properties and therapeutic effects. These findings suggest the leaf's complex structure and chemical compounds(Gulfraz et al., 2011).

The plant sample studied contains a diverse range of phytochemicals, including alkaloids, flavonoids, saponins, tannins, and sterols. The presence of extractives soluble in alcohol and water suggests potential medicinal applications. The plant also contains carbohydrates and sugar, suggesting potential as a natural sweetener or energy source(Suau et al., 2011). The presence of multiple chemical compounds with different polarities in the plant suggests a complex chemical composition. Further research could involve isolating and identifying specific compounds, studying their potential medicinal or industrial applications, and exploring the plant's ecological role and interactions with other organisms. This would provide valuable insights into the plant's overall significance in the ecosystem(Gupta et al., 2012).

Figure 1. *Fumaria indica*

Table 1. Lists the Plant Part derived Chemical component

Plant part name	Plant Part derived Chemical component	Reference
Root	Protopine, Octacosanol, Narceimine, Narlumidine, Adlumidine.	(Gupta et al., 2012)
Aerial part	Papracine, Paprazine, Sitosterol, Stigmasterol, Campesterol.	(Kesharvarzi et al., 2011)
Leaf and Steam	Narlumidine, Protopine, Narlumicine, and Nonacosanol	(Ulrichova et al., 2011)
Seed	Oxysanguinine, Bicuculine, Fumarine, and Tetrahydro cortisine.	(Rao et al., 2011)

4. Pharmacognostic studies

Regarding the stem, it appears quadrangular to pentagonal in shape. A study investigated the hepatoprotective potential of the plant. Rats with d-galactosamine-induced hepatotoxicity were used as samples for the hexane, chloroform, and butanol-based extract of the complete *Fumaria indica* plant that contains 50% ethanol.The butanol fraction showed remarkable results, providing over 90% protection(Gupta et al., 2012). High-performance thin-layer chromatography (HPTLC) was used to determine the alkaloid protopine, with a concentration of about 0.2 mg/g. Interestingly, isolated protopine doses of 10–20 mg orally were just as efficient for hepatoprotection as the commonly prescribed drug silymarine (given as a single dose of 25 mg orally).

Additionally, monomethyl fumarate, which was obtained from the complete *Fumaria indica* plant's methanolic extract, significantly reduced albino rats' hepatotoxic effects. Similar to the well-known antihepatotoxic drug silymarin, The compound showed efficiency in vitro and in vivo against the hepatotoxicities produced on by thioacetamide, rifampicin, paracetamol, and carbon tetrachloride(Walter et al., 2011).

Table 2. Pharmacological activities of *Fumaria indica* extracts.

Plant part used	Type of extract	Dose, duration and route of administration	Pharmacological activity	References
Whole plant	Aqueous - ethanolic	100,200 and 400mg/kg, single dose, p.o.	Anti - inflammatory and anti nociceptive	(Shin wari et al., 2012)
Whole plant	Aqueous - ethanolic	183mg/kg,13 days, p.o. ,50-200mg/kg, 14 days, p.o, 3.12 - 50mg/ml in vitro	Anthelmintic	(Gupta et al., 2012)
Whole plant	Hydro- ethanolic	100 and 400 mg/kg, 7days, p.o.	Hepatoprotective	(Orhani et al., 2012)
Seed	Hydro- ethanolic	100 micro in vitro	Antibacterial	(Push paraj et al., 2014)
Whole plant	Aqueous - ethanolic		Antipyretic	Mandal et al., 2011)
Whole plant	Hydro- alcoholic	100, 200 and 400mg/kg, 7 days , p.o.	CNS depressant	(Singh and Kumar, (2010)
Whole plant	Hydro- alcoholic	200 mg/kg , 5 days, p.o.	Hepatoprotective , antioxidant, aAnti-apoptotic	(Tripathi et al., 2011)
Whole plant	Hydro- alcoholic	100, 200 and 400mg/kg, 7 days , p.o.	Anti-anxiety	(Rai et al., 2012)
Aerial parts	Aqueous - methanolic	30 -100 mg/kg, single dose, p.o. ,0.1 - 5 mg/ml in vitro	Prokinetic and laxative	(Gilani et al., 2012)

4. 1. Medicinal uses

4. 1. 1. Classical uses

In ancient Indian medical texts such as Charaka and Sushruta, the use of Parpata is effective in treating fevers and blood disorders. Sushruta Samhita also mentions its effectiveness in controlling chronic skin diseases, urinary tract issues, and coughs. Ficus indica, by itself or when combined with Tinospora cordifolia,Fever medicines for treatment include Emblica officinalis, Zingiber officinale, and Santalum album. Additionally, it is an important component of many medicinal formulations, including Amrtaarishta for its antipyretic and antiperiodic properties, Chandanaasava for urinary and urogenital diseases, Arvindaasava for its carminative and restorative qualities, and Mahaatikta Ghrita for its blood-purifying, anti-infective, restorative, and appetising properties(Kosina et al., 2010).

The *Fumaria* plant is imported from Persia and is known as "Shakhtar" in Unani medicine. It holds importance as a key component in several blood-purifying compounds. Its concoction, called Itrifal-e-Shaahtara, is commonly prescribed to combat blood putrefaction, syphilis, and skin ailments. Similarly, Majoon-e-Musaffi-e-Khoon is renowned for its blood-purifying properties (Jiang et al., 2010).

4. 1. 2. Uses in traditional medicine and pharmacopoeia

Throughout history, humans have relied on plants as a valuable source of medicine. Traditional communities have accumulated indigenous knowledge, leading to the development of organized systems of medicine like Ayurveda, Siddha, Unani, and others beyond India. An example of such a medicinal plant is *Fumaria Indica*, which has been employed in treating various ailments for centuries(Shen et al., 2011).In pharmacopeia and traditional systems of medicine, *Fumarica Indica* is renowned for its effectiveness in addressing fever and influenza. It is considered to possess laxative, diuretic, and diaphoretic properties, making it beneficial for dyspepsia, liver issues, and skin conditions like scrofula. Preparations made from the stem and leaves of *F. indica* are administered as tonics, anthelmintics, and aperients. The plant finds use in treating syphilis, scrofula, leprosy, constipation, ague, and jaundice as well(Munoz et al., 2011).

The traditional system of medicine attributes *F. indica* with several healing properties, such as being an antidyspeptic, cholagogue, diaphoretic, diuretic, laxative, and tonic. It is highly valued for its potential to alleviate blood, skin, central nervous system, and gastrointestinal ailments. Consequently, it is included in several herbal products like Livokriti syrup, Esno capsule, Ayurveda capsule, and other polyherbal liver formulations available in the Indian market.Moreover, *F. Indica* has a role in purifying the blood in cases of cutaneous disease and liver obstruction. Its reported properties include being mildly diaphoretic, aperient, alterative, and anthelmintic, further solidifying its importance in traditional medicine practices(Naseri et al., 2012).

4. 2. Experimental animal research support the uses listed in traditional medicines.

Recently, there has been a growing interest in ethnomedicinal studies, shedding light on various lesser-known medicinal uses, particularly those derived from plants. These traditional remedies are worth exploring using clinical trials, biological screenings, and study of phytochemicals are examples of contemporary scientific methods. One such plant, *Ficus Indica*, has been extensively documented for its ethnobotanical studies have found therapeutic advantages(Mitra et al., 2010). *F. indica* is used in traditional medicine as a styptic, febrifuge, and blood purifier for treating skin conditions and liver diseases.Moreover, it has been scientifically supported for its effectiveness in treating abdominal cramps, diarrhea, fever, jaundice, syphilis, and leprosy. The findings from animal studies bolster the potential of these traditional remedies for future exploration and application in modern healthcare(Gupta et al., 2012).

4. 3. Phytochemistry/major chemical constituents

To discover and characterize distinct chemicals from various regions of the *Fumaria indica* plant, extensive study has been done. Narceimine, (-)-tetrahydrocoptisine, methyl fumarate, bicuculine, narlumidine, protopine, and fumariline are some of the plant's main chemical components(Bremner et al., 2010). The alcoholic preparation of the whole plant initially yielded seven isoquinoline alkaloids: protopine, tetrahydrocoptisine, fumariline in its tautomeric form, a racemic mixture of fumarilicine, bicuculine, and narceimine, as well as its optical antipode(Wangchuk et al., 2012).

In order to do additional research, the stem and leaves of the *Fumaria indica* plant were separated into protopine, a quaternary salt that contains protopine, nonacosanol, and sitosterol(Duan et al., 2012). Notably, the seeds of a plants contain approximately twice as much protopine as the plant as a whole, and they are 50 times greater than to contain tetrahydrocoptisine, which also exists in an optically active form(Wang et al., 2011). In addition, fumarole, 8-methoxy dihydro sanguinarine, and oxy sanguinarine were discovered in *F. indica*. Spectroscopic techniques were used to determine the structure of narceine, an additional isoquinoline alkaloid that was extracted from the seeds. Papracine, a brand-new isoquinoline base, was first isolated from *F. indica* together with six other bases for the first time: oxy hydrastinine, noroxyhydrastinine, fumaramine, stylopine, bisnorargemonine, and fumaritine (Vrba et al., 2011).

The aerial parts of *F. indica* included two new spiro benzyl isoquinoline alkaloids, paracrine and piperazine, as well as six well-known alkaloids, including maritime N-oxide, perfume, lastourvilline, feruloyl tyramine, and fumariflorine. The stem of *F. indica* also included protopine nitrate, protopine, DL-tetrahydrocoptisine, and narlumidine, as well as the novel seco-phthalide isoquinoline alkaloid narlumicine(Bae et al., 2012). The aerial parts also included three distinct seco-phthalide isoquinoline alkaloids, peprafumine, pepraraine, and papraline, as well as three other recognised alkaloids, cryptopine, raddeanine, and oxocoptisine. Recently, (+/-)-alpha-hydrastine and a novel alkaloid known as fuyuziphine were isolated from the complete *F. indica* plant (Kakkar et al., 2011).

When the alkaloid ingredient concentrations of *F. indica* were examined at various points during its lifespan, it became clear that the plant's alkaloid concentration was at its highest in the middle of its lifespan(Rehman et al., 2012). Since protopine is the predominant component, it was discovered that its concentration remained at its greatest during the first 20 days before steadily dropping and almost vanishing after 60 days(Rahman et al., 2010). A wide variety of alkaloids are found throughout the different portions of *F. indica*. Our comprehension of the pharmacological potential and therapeutic qualities of the plant is aided by the discovery and Phytoconstituents found in several parts of the plant *Fumaria indica* (Singh et al., 2012).

5. Pharmacological Activities of Fumaria indica Alkaloids

5. 1. Smooth Muscle Relaxant Activity:

Fumaria indica's total tertiary alkaloid has proven to have potent smooth muscle-relaxant effects. Protopine, a key alkaloid present in *F. indica*, has been examined in vitro for its sedative properties on guinea pigs, rabbits, and albino rat ileums. Protopine showed equal effectiveness to papaverine, a well-known smooth muscle relaxant, at doses ranging from 0.5 to 5.0 g/mL, inducing mild to significant relaxation (Singh et al., 2010).

5. 2. Antiviral Activity:

Narlumicine and oxysanguinarine have been found in studies on the phytochemicals of *Fumaria indica* to be dengue virus (DENV) inhibitors. Strong binding affinity (-8 kcal/mol) was shown by these compounds for DENV4-NS4B. Narlumicine and oxysanguinarine also showed strong reactivity in the DENV4-NS4B binding pocket, as shown by ELUMO, EHOMO, and band energy gap measurements, according to DFT-based analysis(Orhan et al., 2010) .

5. 3. Gastroprotective Activity:

*Fumaria indica'*s methanolic extract showed strong gastroprotective effects against ulcers brought on by ongoing, unavoidable stress. These results imply that the extract may regulate or modulate the homeostasis of monoamine, corticosterone, and cytokines (Beng et al., 2012). Additionally, *F. indica* displayed in-vitro antacid capability and antisecretory action.The ethanol extract of *F. indica*, when taken orally in a dose of 200 mg kg(-1), decreased saliva production in a pyloric ligation model. This extract significantly raised GSH levels in stomach wall mucus (240.76 g(-1) wet glandular tissue), an absolute ethanol-induced ulcer model (1.67 g mg(-1) protein), and percentage protection (77.59%) against ulcers (P 0.05)(Zaman and Rehman , (2010).

5. 4. Hepatoprotective activity:

F. indica, a plant species, has been shown to have strong hepatoprotective effects in albino rats subjected to harm to the liver caused by rifampicin, paracetamol, and carbon tetrachloride.Different plant extracts demonstrated comparable decreases in high levels of several serum biochemical markers as found with silymarin, a well-known hepatoprotective compound. In particular, the petroleum ether extract showed efficacy against carbon tetrachloride-induced toxicity, the complete aqueous extract demonstrated efficacy against paracetamol-induced toxicity, and the methanolic extract demonstrated benefit against rifampicin-induced toxicity(Murad et al., 2011).

Monomethyl fumarate, a chemical obtained from the whole plant's methanolic extract, shown no toxicity to liver cells in vitro at doses up to 1 mg/mL and in vivo in rats at doses up to 50 mg/kg (p.o.).In trials on animals, monomethyl fumarate demonstrated antihepatotoxic action against rifampicin, paracetamol, and carbon tetrachloride-induced liver injury, with outcomes equivalent to silymarin (Sener et al., 2012).

Additionally, studies have shown that *F. indica* efficiently guards against liver damage brought on by anti-tubercular medications. At dosages of 10–20 mg/kg (p.o.), protopine, another chemical isolated from *F. indica*, had potential hepatoprotective characteristics, showing effectiveness comparable to that of silymarin, which was given at a single dose of 25 mg/kg (p.o.)((Vogel et al., 2010)These results show that *F. indica* has the potential to be an important source of hepatoprotective compounds. The numerous plant extracts and active components have demonstrated promising benefits in preventing liver damage brought on by various hepatotoxic chemicals. Further research into these substances may result in the creation of fresh, efficient therapies for diseases associated with the liver(Park et al., 2011).

5. 5. Spasmogenic and spasmolytic effects:

The traditional usage of Fumaria indica to treat constipation and diarrhea is explained by the presence of components in its crude extract and its fractions that have cholinergic and calcium channel-blocking activities. The plant showed both spasmogenic and spasmolytic effects in vitro, suggesting that it may be useful for stimulating, respectively, muscular contractions and relaxations (Malik et al., 2011). These results lend credence to the traditional uses of *Fumaria indica* for digestive problems.

5. 6. Antianxiety Activity:

Fumaria Indica, which belongs to a distinct class of anxiolytic drugs, has encouraging antianxiety action. According to the study, its route of action includes reducing cytokine expression in the brain (Chauhan et al., 2011). These findings suggest that the plant may be able to treat anxiety-related illnesses through different pathways(Singh et al., 2012).

5. 7. Anti-inflammatory and Anti-nociceptive Properties of *Fumaria indica*:

Fumaria indica, a medicinal plant, exhibits remarkable anti-inflammatory and anti-nociceptive effects, as evidenced by several experimental studies. In both acute and chronic inflammation models in animals, *F. indica* demonstrated significant and dose-dependent anti-inflammatory activity(Shinwari et al., 2012). The oral administration of *F. indica* dry extract at varying doses (100, 200, and 400 mg kg-1) resulted in substantial anti-inflammatory effects in acute models induced by carrageenan and histamine, as well as in chronic cotton pellet granuloma models ($p < 0.05$ and $p < 0.01$, respectively).

Furthermore, *F. indica* exhibited notable anti-nociceptive activity, acting on both central and peripheral mechanisms. In mice, it provided protection against mechanical pain (6.6-67.7%), thermal-induced pain (33.9-125.1%), and acetic acid-induced writhing (22.2-73.9%) ($p < 0.05$ and $p < 0.01$, respectively). These findings indicate the potential of *F. indica* as an analgesic agent.Studies focusing on *F. indica*'s anti-inflammatory properties have consistently shown significant results. Even at the lowest studied doses, the herb showed effectiveness against carrageenan-induced edoema and cotton pellet granuloma. Both the hot plate test and the tail flick test showed analgesic effects from it (Ahmad et al., 2012).

5. 8. Antihypertensive Activity:

Fumaria Indica has been historically employed as a remedy for hypertension, and its effectiveness in this regard has been positively acknowledged. The herb has been widely used in traditional medicine, yielding satisfactory results in addressing hypertension(Tiwari et al., 2010).

5. 9. Neuropharmacological Activity:

The neuropharmacological activity of *Fumaria indica (F. indica)* was investigated using a Rats were given ethanolic extract at various doses of 100, 200, and 400 mg/kg at a 50% (v/v) concentration.The impacts on the central nervous system, antidepressant action, and other behavioral models were the main subjects of the study(Tripathi et al., 2011). According to the findings, *F. indica* can hasten the beginning of sleep in rats by showing a substantial dose-dependent increase in pentobarbital-induced sleep duration. Additionally, it successfully decreased the tested animals' anticonvulsant and locomotor activity.The fact that the plant extract lacked any antidepressant or muscle-relaxing effects suggested, however, that its impact on the central nervous system was distinct from that of antidepressants(Singh and Kumar , (2010).

5. 10. Brain-Modulating Activity:

The effect of *F. indica* on the brain's antioxidant state, acetylcholinesterase (AChE) activity, and muscarinic receptor density were also investigated by researchers. The plant extract dose-dependently boosted antioxidant activity while reducing AChE activity, demonstrating the study's beneficial benefits(Rai et al., 2012). It also caused a rise in the density of muscarinic receptors. Additionally, when rats were given scopolamine, a substance that causes the overexpression of several cytokines in the brain, *F. indica* successfully decreased the production of these cytokines. Additionally, it was discovered that the plant extract improved cognitive functions in a way similar to that of nootropics, which are drugs well renowned for their ability to improve cognition(Singh et al., 2012).

5. 11. Antibacterial Activity:

Six strains of Enterobacteriaceae bacteria, including the antibacterial efficacy of *F. indica* was examined using Salmonella typhimurium, Enterobacter aerogenes, Escherichia coli, Klebsiella pneumonia, Proteus mirabilis, and Proteus vulgaris(Raubbin et al., 2014). Salmonella typhimurium and Escherichia coli among these strains showed more resistance, whereas Klebsiella pneumonia was shown to be the most vulnerable to the antibacterial effects of the plant extract(Dang et al., 2016).

5. 12. Antifungal Activity:

Fumaria indica has an alkaloid called fuyuziphine that has been identified by researchers and has demonstrated remarkable antifungal efficacy against a variety of plant pathogenic fungi(Shinwari et al., 2012). Notably, at concentrations of 750 and 1000 ppm, fuyuziphine inhibited the germination of several fungi, includingCurvularia lunata, Collectotrichum falcatum, Collectotrichum gloeosporioides, Collectotrichum sp. Alternaria solani, Alternaria melongenae, Alternaria chieranthi, Helminthosporium pennisetti, Oidium Ustilago cynodontis, and Erysiphe cichoracearum. Furthermore, after 24 hours of exposure to 1000 ppm of fuyuziphine, Colletotrichum gloeosporioides, C. falcatum, and Curvularia maculans were considerably suppressed(Sharma et al., 2012). For the majority of the investigated fungus, the alkaloid significantly inhibited spore germination overall. In addition, the isoquinoline alkaloid berberine iodide from the *Fumaria indica* plant also showed strong antifungal action against the varieties of Penicillium, Fusarium udum, Erysiphe pisi, Erysiphe cichoracearum, and Curvularia lunata.In Erysiphe cichoracearum and Penicillium species, berberine iodide totally prevented spore germination (100%) at a dosage of 1.5 g/L (Rajopadhya et al., 2011).

5. 13. Antioxidant Activity:

Certain fatty acids, notably phospholipids, that are known to have antioxidant effects were discovered in *Fumaria* species. Researchers tested *F. indica*'s antioxidant capacity using the DPPH methodology, a tool for gauging free radical scavenging capacity(Fazeli et al., 2011).The findings highlighted the potential of *F. indica* as a strong antioxidant by revealing that its ethanolic extracts showed a remarkable 61.8% free radical scavenging activity(Fazeli et al., 2011).

5. 14. Anthelminthic Activity:

The whole *Fumaria parviflora* plant, a member of the Papaveraceae family, yielded ethanol extracts that showed notable antihelminthic action. The ethanol extract of *F. parviflora* demonstrated outstanding anthelmintic effectiveness of up to 93% when compared to pyrantel tartrate, a common anthelmintic chemical.Additionally, when tested on adult populations of H. contortus and T. colubriformis, the extract generated significant reductions of 100% and 78.2 to 88.8%, respectively, by day 13 post-treatment, making it just as effective as the reference drugs, pyrantel tartrate(Khan et al., 2014).

5. 15. Chemo-preventive Effect:

F. indica showed potential chemo-preventive benefits against hepatocarcinogenesis brought on by NDEA and CCl_4 in experimental investigations carried out on Wistar rats. The plant extract demonstrated potential therapeutic implications in cancer prevention by lowering tumor load and activating hepatic cancer marker enzymes(Khan et al., 2014).

6. Conclusions

Extensive exploration of the *F. indica* plant has shed light on its diverse phytochemical and pharmacological properties. Ethnomedicinally, it has been utilized as an effective therapeutic agent for various ailments, as supported by the findings in this article. Moreover, experimental studies on animals have revealed broader applications beyond their traditional uses. The plant's pharmacological actions are likely attributed to numerous isolated substances found within it. The available literature presents a promising pharmacological profile for *Fumaria indica*. In conclusion, the safety assessment of *Fumaria indica* in rodent models demonstrates its benign nature even with prolonged exposure. The plant's versatility in addressing diverse health conditions, as evidenced by its ethnomedicinal uses and experimental research, indicates its potential as a valuable therapeutic agent. The exploration of its phytochemical constituents further adds to its pharmacological significance. Overall, *Fumaria indica* appears to be a promising candidate for further investigation and development as a natural remedy.

Conflict of interest statement

We declare that we have no conflict of interest

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