Review Article

A review on Pharmacological potential of *Solanum nigrum*: Pharmacological review on *Solanum nigrum*

B.M Thejaswini[1], Satish S[2], Ramkrishna Shabaraya A[3]

From [1]PG Scholar, [2]Professor, Department of Pharmacology, [3]Principal and Head of the Department of Pharmaceutics, Srinivas College of Pharmacy Valachil, Farangipete post, Mangalore, Karnataka - 574143.

ABSTRACT

Solanum nigrum, commonly known as black nightshade, is a plant species that belongs to the family Solanaceae, used in traditional medicine systems in various parts of the world for its potential pharmacological properties. The present study is an attempt to review the pharmacological potential of *Solanum nigrum*. *Solanum nigrum* contains several bioactive compounds, including phenolic compounds and flavonoids, which exhibit significant antioxidant activity. Studies have demonstrated that *Solanum nigrum* possess anti-inflammatory effects. *Solanum nigrum* has shown promising anticancer activity in preclinical studies, its extracts have exhibited cytotoxic effects against various cancer cell lines, including lung, breast, colon, and liver cancers. The phytochemicals present in this plant are believed to induce apoptosis (cell death) and inhibit the growth of cancer cells. Several studies have reported the antimicrobial potential of *Solanum nigrum* against various pathogens, including bacteria, fungi, and viruses. *Solanum nigrum* has been investigated for its hepato-protective properties. Some research suggests that *Solanum nigrum* may have anti-diabetic properties, reported to possess hypoglycaemic activity. While these studies highlight the potential pharmacological properties of *Solanum nigrum*, it is important to note that further research is still needed to fully understand its mechanisms of action and evaluate its safety and efficacy in humans.

Key words: Black nightshade, Pharmacological potential, *Solanum nigrum*, Apoptosis.

Medicinal plants have been used by humans for centuries in folklore medicine [1]. More than 2000 species belonging to the genus solanum (Solanaceae family) are found in tropical and subtropical areas of the world. *Solanum nigrum* has been used traditionally to treat various ailments such as pain, inflammation fever and enteric diseases [2]. It is also used against sexually transmitted diseases [3]. Throughout history, *Solanum nigrum* has been used in traditional medicine systems in different cultures for its potential medicinal properties. The plant has been emp- loyed to treat various ailments, including inflammation, skin disorders, gastrointestinal issues, and respiratory conditions. It has also been used as a diuretic and to alleviate pain [4].

In addition to its historical use in traditional medicine, *Solanum nigrum* has attracted scientific interest due to its phytochemical composition and potebtial pharmacological activities. The plant contains various bioactive compounds, including alkaloids, flavonoids, phenolic compounds, and glycoalkaloids such as solasonine and solamargine. These compounds are believed to contribute to the plant's pharmacological effects, including antioxidant, anti-inflammatory, antimicrobial, anticancer, hepato-protective, and anti-diabetic activities [5]. *Solanum nigrum*is a weed of nitrogen rich soils, amentaceous areas and gardens. An infusion of the plant is used as an enema in infants having abdominal upsets. It is a household remedy for anthrax pustules and is applied locally. Freshly prepared extract of the plant is effective in the treatmentof cirrhosis of the liver, and also serves as an antidote to opium poisoning [6]. While *Solanum nigrum* shows promise as a medicinal plant, it is important to note that further research is needed to fully understand its mechanisms of action, determine optima dosage, and assess its safety profile.

Access this article online

Received – 26th May 2023

Initial Review – 30th May 2023

Accepted – 10th June 2023

Quick Response Code

Correspondence to: B.M Thejaswini, PG Scholar, Department of Pharmacology, Srinivas College of Pharmacy Valachil, Farangipete post, Mangalore, Karnataka, India. **Email:** bm17thejaswini@gmail.com

Vernacular Names and Taxonomical Classification: *Solanum nigrum* belongs to the family Solanaceae with common names of black nightshade or garden night shadeis a plant species that belongs to Plantae (Kingdom}, Magnoliophyta (Division), Magnoliopsida (Class), Solanales (Order), Solanum (Genus), *Solanum Nigrum* (Species). Vernacular nameincludes Black nightshade (English), Ganikesopu (Kannada), Manatakkali (Malayalam), Makoya, Kakamachi (Hindi), Kaakesoppu (Tulu) [7, 8, 9]. The plant *Solanum nigrum L.* (Solanaceae), commonly known as 'herbal mora', is a common herb that grows wild and abundantly in open fields, whose fruit is used in Mexico's traditional medicine as a nervous tonic [10]. It is a little herbaceous plant that is now spread around the world. Tiny white or purple flowers, black tiny berries, and dark green leaves are the distinguishing features of *Solanum nigrum*.

Habitat and Distribution: Crop weed *Solanum nigrum* is widespread. It is an annual plant with a brief lifespan reaching a height of 1.25m. These are mostly used as source of vegetables and fruits by harvesting the plants that emerge naturally as weeds in fields that have been cultivated, or in weed plant communities, in moist habitats, along fences and highways, in shaded regions, close to buildings, and on vacant ground. There are a few reports of garden huckleberries being grown for their fruits in North America [4, 9]. Only a few countries fully cultivate these species. They are quite prevalent in India, mostly in the states of Karnataka, Odisha, and Tamil Nadu (Nilgiris). They can be found by riverbanks, damp areas, fallow plains, and arable regions. The *Solanum nigrum* plant is well adopted to the Mediterranean region. It is continuously dispersed across India's Eastern Ghats, as well as in the southern and central areas, which have tropical wet climates [11].

Botanical Description: Black nightshade is a short-lived herbaceous plant or small shrub. Plants are about 0.25-1m tall [12]. The entire plant is covered with simple pubescent hairs which are angular and are coarsely pubescent on the stems [13]. It shows tap roots with few branches and numerous small lateral roots pale brown, easily peeled off exposing pale yellow wood. It also has erected glabrous or pubescent green, slightly woody unbranched stem [4].

LEAVES

The leaves are ovate, the bases are cuneate, 4-10 and 3-7cm wide, pubescent, coarsely dentate, the apex is obtuse and shortly pointed [14]. The leaves are dull dark green, and toothless to slightly toothed on the margins [4]. The petiole is about 1-2cm long. The cuneate of the leaf is base wedge shaped to broad and descending to the petiole, with irregular wavy coarse teeth throughout or on each side and smoother soft, and hairy on both sides with five to six veins on both sides (Figure 1) [12].

Figure 1. *Solanum nigrum* leaves [Photo By; Own work]

Phytochemicals in leaves: Investigation of the *Solanum nigrum* leaves reported that it contains the substances, such as alkaloid, flavonoids, tannins, saponins, glycosides, proteins, carbohydrates, coumarins & phytosterols. It has been found that *Solanum nigrum* contains substances such as steroid alkaloid, steroidal saponins and glycoprotein [15]. *Solanum nigrum* contains two quercetin glycosides namely, quercetin +.3-O-(2Gal-_-rhamnosyl)-_-glucosyl (1_6)-_-galactoside and quercetin 3-O-_-rhamnosyl (l_2)-_-galactoside. Also, previously known quercetin 3-glucosyl (l_6) galactoside, 3-gentiobioside, 3 - galactoside and 3-glucoside, were also found [16]. *Solanum nigrum* possesses numerous compounds that are responsible for pharmacological activities. Its active components are glycoalkaloids, glycoproteins, and polysaccharides, polyphenolic compounds such as gallic acid, catechin, protocatechuic acid (PCA), caffeic acid, epicatechin, rutin, and naringenin [17].

Alkaloids: Leaves contain alkaloids, including solanine and solanigrine. These alkaloids have been studied for their potential antimicrobial, anticancer, and anti-inflammatory activities [18].

Flavonoids: Leaves are rich in flavonoids, which are known for their antioxidant and anti-inflammatory properties. Flavonoids found in the leaves include quercetin, kaempferol, and rutin [8].

Phenolic compounds: The leaves also contain phenolic compounds, which contribute to their antioxidant activity. These compounds help scavenge free radicals and protect against oxidative stress [19].

Vitamins: Leaves are a good source of vitamins, including vitamin C, vitamin A, and vitamin E. These vitamins contribute to overall health and well-being [20].

Minerals: Leaves contain various minerals such as calcium, iron, and potassium, which are essential for proper bodily functions [20].

Saponins: Saponins are another class of phytochemicals found in *Solanum nigrum* leaves. These compounds have been studied for their potential antifungal, antimicrobial and anti-inflammatory activities [21]. The leaves of *Solanum nigrum* have been traditionally used for various medicinal purposes. Following is some of the reported medicinal uses of *Solanum nigrum* leaves, It is important to note that while *Solanum nigrum* leaves have a history of traditional use for these medicinal purposes, following are the some of the uses of *Solanum nigrum* leaves.

Antioxidant activity: *Solanum nigrum* leaves contain antioxidants that help scavenge free radicals and protect against oxidative stress. Consumption of the leaves or preparations made from them may contribute to overall antioxidant support in the body [19].

Diuretic properties: *Solanum nigrum* leaves have diuretic effects, which means they promote increased urine production. This property has been traditionally used to help flush out toxins from the body and support urinary health [12].

Respiratory conditions: The leaves of *Solanum nigrum* have been used to alleviate respiratory ailments like cough, asthma, and bronchitis. They may be consumed as an infusion or decoction to help soothe the respiratory system [7].

Gastrointestinal support: *Solanum nigrum* leaves have been used to promote digestive health. They may be consumed to relieve constipation, indigestion, and stomach discomfort. Additionally, they are believed to possess mild laxative properties [8].

Anti - microbial activity: The chloroform: methanol extracts of leaf of *Solanum nigrum* showed maximum inhibitory activity against *Pseudomonas aeruginosa*. The chloroform: methanol extract of stem of *Solanum nigrum* was highly active against *Bacillus subtilis* and the acetone extract against *Pseudomonas aeruginosa*. Thus, it revealed that leaves and stem of *Solanum nigrum* possess anti-microbial activity [22].

Anti-inflammatory properties: The leaves of *Solanum nigrum* possess anti-inflammatory properties and have been used to alleviate inflammation-related conditions. Methanolic extract of whole plant of *Solanum nigrum* was investigated using carrageenin-induced rat paw oedema and egg white induced hind paw oedema methods, which demonstrated that plant extract exhibited anti-inflammatory activity [23]. The lipid-soluble extract of *Solanum nigrum* leaves possessed anti-inflammatory activity [24].

Hypoglycaemic activity: The crude ethanolic extract of *Solanum nigrum* on blood sugar of albino rat after daily oral administration of dose at the level of 250mg/kg b. wt. for five and seven days respectively. It was noticed that the chronic administration for longer duration leads to significant decrease in blood sugar compared to control. Thus, it is concluded that *Solanum nigrum* also has the antidiabetic property. The aqueous and hydro-alcoholic extracts of different parts of *Solanum nigrum* plant, viz leaf, fruit and stem evaluated for hypoglycaemic activity in Sprague Dawley rats. Results indicated that aqueous extracts of leaf and fruit possess significant hypoglycaemic effect in dose dependent manner, followed by hydro alcoholic extracts [25].The stem extract of *Solanum nigrum* has no profound effects [26].

Anti-seizure property: Of the aqueous extract of the leaves of *Solanum nigrum* was evaluated inchicks, mice and rats. The aqueous leaf extract produced a significantly ($P<0.05$) dose dependent protection against electrically-induced seizure in chicks and rats, pentylenetetrazole-induced seizure in mice and rats and picrotoxin-induced seizure in mice and rats. The anti-seizure property of the extract was potentiated by amphetamine. Thus, study suggests that the leaves of this plant may possess anti-convulsant property in chicks, mice and rats [27].

Hepatoprotective effects: Of *Solanum nigrum* water and methanolic extracts were studied in rats. The water extracts showed a hepatoprotective effect against CCl 4 -induced liver damage, the methanolic extracts of *Solanum nigrum* also had hepatoprotective effects with levels of serum AST, ALT, ALP and bilirubin decreasing significantly in animals treated with *Solanum nigrum* methanolic extract compared to an untreated group. The *Solanum nigrum* extract significantly lowered the CCl4-induced elevation of hepatic enzyme markers and decreased superoxide and hydroxyl radical generation [28].

Mosquito larvicidal activity: The crude and solvent extracts of *Solanum nigrum L*. leaves were evaluated against *Culex quinquefasciatus*. The results indicated that the mortality rates at 0.5% concentration were highest amongst all concentrations of the crude extracts. The results of regression analysis of crude extract of *Solanum nigrum* revealed that the mortality rate is positively correlated with the concentration of the extracts. Results of this analysis showed that the ethyl acetate extract of *Solanum nigrum* may be considered as a potent source of a mosquito larvicidal agent [29].

Defence against lead acetate induced toxicity: The protective effect of an aqueous leaf extract of *Solanum nigrum* extract was examined against lead acetate Swiss albino mice. The results of the present study provide clear evidence of defence provided by *Solanum nigrum* extract against lead acetate induced toxicity in brains of albino mice [30].

FLOWERS

The flowers of *Solanum nigrum* have petals greenish to whitish. The inflorescence is extra axillary and composed of 3-6- flowers. The total pedicel is about 1–2.5 cm long, and the pedicel is about 5 mm long and pubescent. The calyx is small, shallow cup shaped, about 1.5–2 mm in diameter, the corolla is white. The lobes are ovoid and oblong about 2 mm long. The filaments are short, anthers are yellow, about 1.2 mm long, and about four times the length of the filaments, and the apical hole is inward. The ovary is ovate and about 0.5 mm in diameter, and the style is about 1.5 mm long. The stigma is small (Figure 2) [31].

Figure 2. *Solanum nigrum* flowers [Photo By; Own work]

Phytochemicals in flowers: The flowers of *Solanum nigrum*, contain various phytochemicals that contribute to their potential medicinal properties. While research on the specific phytochemical composition of *Solanum nigrum* flowers is limited, following are some of the phytochemicals that may be present [32, 33]

Flavonoids: Flavonoids are a class of compounds known for their antioxidant and anti-inflammatory properties.

Glycoalkaloids: *Solanum nigrum* flowers may also contain glycoalkaloids, including solanine and solasonine. These compounds are known to have cytotoxic and antitumor properties. However, it's important to note that these glycoalkaloids can be toxic if consumed in large amounts or if the flowers are not properly processed.

Phenolic compounds: Phenolic compounds, including phenolic acids and phenolic glycosides, are commonly found in plant flowers.

Saponins: Saponins are another class of phytochemicals that may be found in *Solanum nigrum* flowers. They have been studied for their potential antimicrobial and anti-inflammatory activities. It's important to note that the phytochemical composition of *Solanum nigrum* flowers may vary depending on factors such as plant variety, growing conditions, and extraction methods. Further research is needed to fully characterize the phytochemicals present in *Solanum nigrum* flowers and their potential health benefits. *Solanum nigrum* have also been traditionally used for their medicinal properties. Although the flowers are not as widely studied as other parts of the plant, they are believed to possess certain medicinal benefits. Following is some of the reported medicinal uses of *Solanum nigrum* flowers:

Anti-inflammatory properties: Like other parts of the plant, the flowers of *Solanum nigrum* are believed to have anti-inflammatory properties. They may be used topically as poultices or extracts to help reduce inflammation and relieve skin conditions such as rashes and irritation [31].

Digestive support: *Solanum nigrum* flowers have been used to support digestive health. They are believed to have carminative properties, which can help relieve gas, bloating, and indigestion. They may also be used to stimulate appetite and improve overall digestion [31].

Respiratory conditions: The flowers of *Solanum nigrum* have been used in traditional medicine to alleviate respiratory ailments. They may be consumed as an infusion or decoction to help soothe coughs, pulmonary tuberculosis and respiratory congestion [1].

Diuretic properties: *Solanum nigrum* flowers are believed to have diuretic effects [13]. Which mean they may help increase urine production and promote detoxification. This property has been traditionally used to support urinary health and assist in flushing out toxins from the body.

FRUIT

The fruits are berry. These Berries are usually broadly ovoid, dull purple and blackish when ripe about 6-10 mm broad, either remains on plants or falls from calyces when ripe [34]. Fruit shows thin, papery epicarp, pulpy mesocarp and axle placentation, seeds lie free in pulp of fruit. The berries of *Solanum nigrum* contains 4 steroidal alkaloid glycosides, Solamargine, Solasonine, α and β-solanigrine. The berries have been found to contain a saturated steroidal genin, which is identified as trigogenin [9]. Total 76 steroidal saponins have been isolated and identified in *Solanum nigrum*. Unripefruits of *Solanum nigrum* have a high concentration of solasodine (Figure 3) [12].

Figure 3. *Solanum nigrum* fruits [1]

Phytochemicals in fruit: The fruits of *Solanum nigrum* contain various phytochemicals that contribute to their potential medicinal properties. Following are some of the phytochemicals found in *Solanum nigrum* fruits [31, 35]:

Solasonine and solamargine: *Solanum nigrum* fruits contain glycoalkaloids such as solasonine and solamargine. These compounds have been studied for their potential anticancer properties.

Flavonoids: *Solanum nigrum* fruits are rich in flavonoids, which are known for their antioxidant and anti-inflammatory properties.

Vitamin C: *Solanum nigrum* fruits are a good source of vitamin C, also known as ascorbic acid. Vitamin C is an essential nutrient that plays a vital role in immune function and acts as an antioxidant in the body.

Carotenoids: *Solanum nigrum* fruits contain carotenoids, which are responsible for their colour. Carotenoids have antioxidant properties and are beneficial for eye health and overall well-being. The fruits of *Solanum nigrum*, have a long history of traditional medicinal use in various cultures. While the fruits are typically consumed in their ripe state, it's important to note that some parts of the plant, including unripe fruits and other plant parts, may contain toxic compounds. Following are some of the reported medicinal uses of *Solanum nigrum* fruits.

Antipyretic activity: *Solanum nigrum* fruits have been traditionally used as a febrifuge, meaning they may help reduce fever. The fruits may be consumed or used in preparations to help lower body temperature during fever episodes [12].

Wound healing: The ripe fruits of *Solanum nigrum* have been used topically to promote wound healing. They are believed to possess antimicrobial and anti-inflammatory properties that can help in the healing process [8].

Digestive health: *Solanum nigrum* fruits have been used traditionally to support digestive health. They are believed to possess laxative properties and may help relieve constipation, also used to treat gastritis and promote regular bowel movements [13]. It is important to exercise caution when consuming *Solanum nigrum* fruits or using them for medicinal purposes. The following are the scientific research validated fruits effectiveness and safety in animal models

Antimicrobial activity: The ethanolic fruit extract of *Solanum nigrum* was found to inhibit the Gram-positive bacteria. SN extract was found to be most effective against *S.aureus* showing the maximum zone of inhibition followed by *B. sublitis* whereas in case of Gram negative bacteria, ethanolic extract was found to be most effective against *E. coli* showing the maximum zone of inhibition followed by *P.aeruginosa*. Interestingly, the ethanolic extract showed high activity against *C. albicans* [36].

Analgesic activity: The *Solanum nigrum* fruit extract was evaluated for its central and peripheral pharmacological actions by using Eddy's hot plate and acetic acid induced writhing respectively, model revealed that the extract possesses analgesic activity [36].

Antioxidant properties: The ripe fruits of *Solanum nigrum* are rich in antioxidants. These antioxidants help neutralize free radicals in the body, protecting against oxidative stress and promoting overall health. The anti-oxidant activity of methanolic extract of berries of the plant *Solanum nigrum* was evaluated by tissue biochemical anti-oxidant profile. The methanolic extract of berries of the plant *Solanum nigrum* possessed anti-oxidant activity [37].

Anticancer activity: The fruits of *Solanum nigrum* were evaluated for anticancer activity on the HeLa cell line. The fruits of *Solanum nigrum* methanolic extract were tested for its inhibitory effect on HeLa Cell Line. The cytotoxicity of *Solanum nigrum* on HeLa cell was evaluated by the Sulforhodamine B colorimetric assay (SRB) and MTT assay. *Solanum nigrum* methanolic extract has significant cytotoxicity effect on HeLa Cell Line [38].

Antiulcerogenic effect: Of the methanolic extract of *Solanum nigrum* berries (SBE) on aspirin induced ulceration in rats with respect to antioxidant status in the gastric mucosa have been investigated. The decreased levels of antioxidant enzymes and increased mucosal injury were altered to near normal status upon pre -treatment with (SBE) when compared to the ulcer induced rats. The results indicated that (SBE) may exert its gastro protective effect by a free radical scavenging action [37].

Anti-Diarrhoeal activity: Of ethanolic dried fruit extract of *Solanum nigrum* against castor oil induced diarrhoea in mice was investigated. The fruit extract showed a significant anti-diarrhoeal activity in mice and in which it decreased the frequency of defecation [14].

Cardio protective activity: The cardio protective activity of methanolic extract of berries of the plant *Solanum nigrum* was evaluated by using global in vitro ischemia-reperfusion injury carried out using doses of 2.5 and 5.0 mg/kg for 6 days per week for 30 days. The results indicate that the extract exhibited significant ($p<0.001$) cardio protective activity against global in-vitro ischemia-reperfusion injury. The methanolic extract of berries of the plant possessed cardio protective activity [39].

Respiratory conditions: The fruits of *Solanum nigrum* have been used to alleviate respiratory ailments, including cough and bronchitis. They may be consumed as a decoction or infusion to help soothe the respiratory system. Petroleum ether, ethanol and aqueous extracts of *Solanum nigrum* berries were screened for the treatment of asthma by the various methods. Active petroleum ether extract showed presence of anti-asthmatic compound, β-sitosterol. The petroleum ether extract of *Solanum nigrum* berries can inhibits parameters linked to the asthma disease [40].

Cytotoxic activity: The ethanolic extract of the dried fruit of *Solanum nigrum Linn*were tested for cytotoxic activity. In the brine shrimp lethality test, the extract showed cytotoxicity significantly with LC50= 63.10µg/ml and LC90= 160µg/ml [41].

SEEDS

The seeds are mostly nearly ovoid, and discoid. About 1.5–2 mm in diameter, and compressed on both sides. Seeds are smooth, minutely pitted and yellow [34]. The seeds have been used in traditional medicine for various purposes (Figure 4).

Figure 4. *Solanum nigrum*seeds [42]

Phytochemicals in seeds: The seeds of *Solanum nigrum* contain various phytochemicals. However, it's important to note that the seeds also contain toxic compounds such as solanine and solanidine, which can be harmful if the seeds are not properly processed. Here are some of the phytochemicals present in *Solanum nigrum* seeds. [18, 31]

Solasodine: Solasodine is a steroidal alkaloid found in *Solanum nigrum* seeds. It possesses anti-inflammatory and antitumor properties and has been studied for its potential therapeutic applications.

Solanidine: Solanidine is another steroidal alkaloid present seeds. It has been studied for its cytotoxic and antitumor activitiesin *Solanum nigrum*

Glycoalkaloids: *Solanum nigrum* seeds contain glycoalkaloids, including solanine and solasonine. These compounds can have toxic effects if consumed in excessive amounts. However, in controlled and processed forms, they may also have potential medicinal applications.

Lipids: *Solanum nigrum* seeds contain high lipid content. Their protein content and minerals elements (Mg being prominent) are considerable and *Solanum nigrum* oil is an important source of linoleic acid.

Phenolic compounds: *Solanum nigrum* seeds also contain phenolic compounds, which contribute to their antioxidant activity. However, it's important to note that the seeds of *Solanum nigrum*, as well as other parts of the plant, contain toxic compounds such as solanine and solanidine. These compounds can be harmful if consumed in large quantities or if the seeds are not properly processed. As a result, caution should be exercised when using *Solanum nigrum* seeds for medicinal purposes following are some reported traditional uses of *Solanum nigrum* seeds:

Anthelmintic properties: *Solanum nigrum* seeds have been used traditionally as anthelmintic. However, it's important to note that the seeds should only be used under the guidance due to their potential toxicity [43].

Skin conditions: The oil extracted from *Solanum nigrum* seeds has been used topically in some traditional remedies for skin conditions such as eczema, itching, and inflammation. However, more research is needed to validate these uses [8]. It is crucial to consult with a healthcare professional or a qualified herbalist before using *Solanum nigrum* seeds for medicinal purposes, on the appropriate dosage and ensure the safe and responsible use of this plant. The following are the scientific research validated seeds effectiveness and safety in animal models.

Antiviral effect: Methanol and chloroform extracts of *Solanum nigrum* seeds exhibited 37% and more than 50% inhibition of HCV respectively at nontoxic concentration. Moreover, antiviral effect of *Solanum nigrum* seeds extract was also analysed against HCV NS3 protease. The results demonstrated that chloroform extract of *Solanum nigrum* decreased the expression or function of HCV NS3 protease in a dose- dependent manner results suggest that extract contains potential antiviral agents against HCV and combination of *Solanum nigrum* extract with interferon will be better option to treat chronic HCV thus it is concluded that seeds of *Solanum nigrum* possess anti-viral activity [44].

Antifungal activity: Thethree solvent extracts from leaf seed and roots of S*olanum nigrum* were assayed for antifungal activity against fungal strains such as *Penicillium notatum Aspergillus niger, Fuserium oxisporium and Trichoderma viridae*. The zone of inhibitions was compared with the standard antibiotics. The organic solvent extracts (ethanol, methanol and ethyl acetate) of seeds were exhibited strong antifungal activity against all the tested fungal strains compared to leaf and root extracts. Among all the extracts ethyl acetate seed extract showed high antifungal activity [45].

CONCLUSION

The whole plant of *Solanum nigrum* has medicinal properties. The leaves and berries are primarily employed as medicines. *Solanum nigrum* has a wide range of therapeutic potential, including antitumor, analgesic, anti-inflammatory, anticancer, antiallergy, antiviral, antioxidant, antibacterial, neuro-protective and hepato-protective activities. Consequently, additional research is necessary to separate the active components from the *Solanum nigrum* extract for the proper drug development to address the health issues by carrying out additional clinical trials.

REFERENCES

1. Bin Nyeem MA, Ur Rashid AM, Nowrose M, et al. *Solanum nigrum* (Maku): A review of pharmacological activities and clinical effects. Int J of Applied Research. 2017; 3(1): 12-17.
2. Rani P, Khullar N. Antimicrobial evaluation of some medicinal plants for their anti-enteric potential against multidrug resistant *Salmonella typhi*. Phytotherapy Res. 18(8): 2004; 670-73.
3. Atanu FO, Ebiloma UG, Ajayi EI. A review of the pharmacological aspects of *Solanum nigrum* Linn. Biotechnology and Molecular Biology Review. 2011; 6(1): 1-7.
4. Pandey A, Dwivedi AL, Tripathi IP. Review Article on Pharmaceutical, Pharmacological Activities and Therapeutic Potential of "*Solanum Nigrum".* Int J of Research in Engineering and Sci. 2021; 9(121): 1-7.
5. Babu V, Deepa MS. Critical review of Kakamachi. Int Education and Res J. 22; 8(8): 48-49.
6. Arunachalama G, Subramanian N, Pazhani GP, et al. Evaluation of Anti-inflammatory Activity of Methanolic Extract of *Solanum nigrum* (Solanaceae). Ind J of Pharm sci. 2009: 5(3): 151-56.
7. Rani YS, Reddy VJ, Basha SJ, et al. A review on *Solanum nigrum.* World J Pharm Pharm Sci. 2017; 6 (12); 293-99.
8. Shenbagam M, Sulthana R. A review: *Solanum nigrum* and its pharmacological activities. Int J Res App Sci Eng Tech. 2022; 10(4); 916-23.
9. Mohamed Saleem TS, Chetty CM, Ramakanth S, et al. *Solanum nigrum Linn*- A Review. 2009; 3(6); 342-4
10. Perez RM, Perez JA, Garcia LM, et al. Neuropharmacological activity of *Solanum nigrum* fruit. J Ethnopharmacol 1998; 62(1): 43-8.
11. Kalidas C, Panda PC. The genus *Solanum L* (Solanaceae) in Eastern Ghats of India. Regional plant resource centre. 2019; 1-76.
12. Chen X, Dai X, Liu Y, et al. *Solanum nigrum Linn*: An Insight into Current Research on Traditional Uses, Phytochemistry, and Pharmacology. Frontiers in pharmacology. 2022; 13: 1-3.
13. Mani RK, Pramashree JB, Bharathi DR, et al. The traditional and pharmacological properties of *Solanum nigrum*: a review. Int J of Indigenous Herbs and Drugs.2022; 7(2): 49-55.
14. Chauhan R, Ruby KM, Shori A, et al. *Solanum nigrum* with dynamic therapeutic role: a review. Int. J. Pharm. Sci. Rev. Res. 2012; 15(1): 65-71.
15. Sadawarti P, Jamdade C, Gurubaxani S. An Overview of Phytochemical and Pharmacological Potentials of *Solanum nigrum Linn*.2022; 1-5.
16. Hameed IH, Calixto R, Hadi MY. A Review: *Solanum nigrum L*. Antimicrobial, Antioxidant properties, Hepato-protective effects and Analysis of Bioactive Natural Compounds. Research J. Pharm. and Tech.2017; 10(11): 4063-65.
17. Ravi V, Saleem TSM, Maiti PP, et al. Phytochemical and pharmacological evaluation of *Solanum nigrum Linn*. African J of Pharmacy and Pharmacology. 2009; 3(9): 454-57.
18. Jayakumar K, Murugan K. Solanum alkaloids and their pharmaceutical roles: a review. J Anal Pharm Res. 2016; 3(6): 11-12.
19. Campisi A, Acquaviva R, Raciti G, et al. Antioxidant Activities of *Solanum nigrum* L. Leaf Extracts Determined in in vitro Cellular Models. 2019; 8(2): 2-12.
20. Sabu S, Kalpana CA. Phytochemical contituents andnutrient composition of fresh and cooked *Solanum nigrum* leaves. Asian J of Multidimensional Res. 2018; 7(2): 231-34.
21. Musto M. Preliminary report on antifungal activity of a *Solanum nigrum* extracts against five mycotoxin-producing fungi. Emirates J of Food and Agriculture. 2015; 27(11): 825-30.
22. Upadhyay P, Ara S, Prakash P. Antibacterial and Antioxidant Activity of *Solanum nigrum* Stem and Leaves. Chem Sci Trans. 2015; 4(4): 1013-17.
23. Ganesan A, Pazhani GP, Subramanian N, et al. Evaluation of Anti-inflammatory Activity of Methanolic Extract of *Solanum nigrum* (Solanaceae). Iranian J of Pharmaceutical Sci. Res. 2009; 5(3): 151-156.

24. Zakira ZA, Sulaiman MR, Zainal H, et al. Aris Antinociceptive, anti-inflammatory and antipyretic effects of *Solanum nigrum* aqueous extract in animal models. Methods Find Exp Clin Pharmacol. 2009; 31(2): 81-8.
25. Ali NS, Singh K, Khan MI, et al. Protective effect of ethanolic extracts of *Solanum nigrum* on the blood sugar of albino rats. Int J of Pharm Sci Res. 2010; 1(9): 97-99.
26. Akubugwo I. E, Obasi N.A, Chinyere G.C et al. Mineral and phytochemical contents in leaves of *Amaranthus hybridus L* and *Solanum nigrum L.* subjected to different processing methods. African J of Biochemistry Res. 2 (2): 2008; 40-44.
27. Wannang NN, Anuka JA, Kwanashie HO, et al. Anti-seizure activity of the aqueous leaf extract of *Solanum nigrum linn* (solanaceae) in experimental animals. African Health Sciences. 2008; 8(2): 74-9.
28. Elhag RAM, Badwi MAE, Bakhiet AO, et al. Hepatoprotective activity of *Solanum nigrum* extracts on chemically induced liver damage in rats. Journal of Veterinary Medicine and Animal Health. 2011; 3(4): 45-50.
29. Rawani A, Ghosh A, Chandra G.N. Mosquito larvicidal activities of *Solanum nigrum L.* leaf extract against *Culex quinquefasciatus*. Parasitol Res. 2010; 1235–40.
30. Chinthana P, Ananthi T. Protective Effect of *Solanum nigrum* and *Solanum trilobatum* Aqueous Leaf Extract on Lead Induced Neurotoxicity in Albino mice. J Chem Pharm Res. 2012: 4(1): 72-74.
31. Mukhopadhyay G, Sarkar S, Kundu S, et al. Ethno-pharmacological activity of *Solanum nigrum*. The Pharma Innovation J. 2018; 7(10): 692-98.
32. Sinani SA, Eltayeb EA.The steroidal glycoalkaloids solamargine and solasonine in *Solanum nigrum* plants. South African J of Botany.2017; 112: 253-69.
33. Kumar J, Kaur A, Narang P. Phytochemical screening and metal binding studies on floral extract of *Solanum nigrum.* 2020; 26: 3332-36.
34. Dilip J, Saroja K, Patel GJ. Pharmacognostic study of kakamachi *Solanum nigrum*. J of Pharmaceutical and Scientific Innovation. 2012; 1(4): 42-48.
35. Romero CAE, Inzunza LAM, Contreras L, et al. Solanum Fruits: Phytochemicals, Bio accessibility and Bioavailability, and Their Relationship with Their Health-Promoting Effects. Frontiers in nutrition. 2021; 8: 1-6.
36. Kaushik D, Jogpal V, Kaushik P, et al. Evaluation of activities of *Solanum nigrum* fruit extract. Archives of Applied Science Research.2009; 1(1): 43-50.
37. Jainu M, Devi CSS. Antioxidant effect of methanolic extracts of *Solanum nigrum* berries on aspirin induced gastric mucosal injury. Indian J of Clinical Biochemistry. 2004; 19 (1): 57-61.
38. Patels S, Gheewala N, Suthar A, et al. In-vitro cytotoxicity activity of *Solanum nigrum* extracts against HeLa cell lines and Vero cell lines. Int J of pharmacy and pharmaceutical sci. 2009; 1(1): 38-46.
39. Bhatia N, Maiti PP, Kumar A, et al. Evaluation of cardio protective Activity of Methanolic Extract of *Solanum nigrum Linn.* In Rats. Int J of Drug Development & Res. 2011; 3(3): 139- 47.
40. Nirmal SA, Patel AP, Bhawar SB, et al Antihistaminic and antiallergic actions of extracts of *Solanum nigrum* berries: possible role in the treatment of asthma J of Ethno pharmacology. 2012; 142(1): 91-7.
41. Karmakar U, Tarafdar UK. Sadhu SK, et al. Biological Investigations of Dried Fruit of *Solanum nigrum Linn.* S J Pharm Sci. 2010; 3(1): 38-45.
42. Werther J. Seeds of *Solanum nigrum*. J Appl Microbiol. 2016; 120(4): 900-911.
43. Saddiqe Z, Maimoona A, Khalid S. Phytochemical analysis and anthelmintic activity of extracts of aerial parts of *Solanum nigrum L*. Biologia (Pakistan) 2013; 59(2); 205-11.
44. Javed T, Usman AA, Sana R, et al. In-vitro antiviral activity of *Solanum nigrum* against Hepatitis C Virus. Virology Journal. 2011; 26.
45. Sridhar TM, Josthna P, Naidu CV. Antifungal Activity, Phytochemical Analysis of *Solanum nigrum (L.)* - An Important Antiulcer Medi. Plant. J of Eco. 2011; 3(7): 11-15.

How to cite this article: B.M Thejaswini, Satish S, Ramkrishna Shabaraya A. A review on Pharmacological potential of *Solanum nigrum*: Pharmacological review on *Solanum nigrum.* Indian J Pharm Drug Studies. 2023; 2(3) 95-102.

Funding: None *Conflict of Interest: None Stated*