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# DECODING THE HEALING POWER OF SOLANUM NIGRUM L.: A REVIEW OF PHARMACOLOGICAL POTENTIAL

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*Solanum nigrum, Black Nightshade, Phytochemistry, Pharmacological properties, Traditional medicine, Antioxidant activity*

## Abstract

Solanum nigrum Linn. Black Nightshade, widely distributed and with a wide supportive pharmacology of action, has been reviewed for its traditional usage, phytochemical components, supportive action, potential toxicity, and potential future directions in this paper. It is traditionally used among different states to treat, among others, skin morbidities, gastrointestinal morbidities, respiratory tracts, as an analgesic, and antipyretic. Phytochemicals: fine yellow-colored flavonoids glycosides, tannins, and saponins are also packed in the genuine parts of the complex. Other phytochemical components contain even better alkaloids. In the explanation of method, analytical work has found some other bioactivity sources. It contains bioactive alkaloids and antioxidants, along with antibiotic, and diabetics properties. This whole sample also contains toxic piggy-backed components such as methylating and controlling solarmargine. Safety is therefore strongly correlated to its usage. It remains as a chance of researching the pathways we know today, including molecular basis, clinical instruction, application of biotechnology types, and close linkage to the exposure of persons and present healthcare.



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## 1. INTRODUCTION

Black Nightshade, a member of the Solanaceae family other notable members being tomatoes and eggplants belongs to *S. nigrum* Linn species. Growing conditions: *S. nigrum* is a cosmopolitan species, found in tropical as well temperate regions around the world For millennia, traditional medicine systems - Ayurveda; Traditional Chinese Medicine and African herbal medicines have identified cannabis for its therapeutic potential [1].

The plant has numerous medicinal uses, curing many types of illness including inflammation, infections and liver diseases to an extent cancer. This multifaceted bioactivity of *S. nigrum* is mostly because the plant contains alkaloids, flavonoids, glycosides tannins and saponin. [2]

*Solanum nigrum* is also suspected of poisoning animals and feed intake reduction owing to the mainly harmful glycoalkaloids such as solanine and solamargine, which can be toxic at larger dose levels. The aforementioned dual-repertoire of such pharmaceutical power as well as poisonous toxicity demands in-depth understanding regarding its properties, identification protocols and methods for the preparation so that it is safely utilised without loss or reduction to its lateral meanings. [3]

The present review presents an overview on experimental and clinical reports of *S. nigrum*, with a special focus on its botanical characteristics, phytochemical constituents, pharmacological activities, traditional uses as well as the safety evaluation. This paper brings together information from different studies to provide the reader a single unified resource for researchers, healthcare providers and practitioners in view of therapeutic potentials and applications of *S. nigrum*. [4]

## 2. BOTANICAL DESCRIPTION

*Solanum nigrum* Linn. *Solandra guttata* Sendtn., known as Black Nightshade, is trailing or erect herbaceous annual or short-lived perennial up to 100 cm tall. It also has a wildly fluctuant morphological character, which has been a major cause of confusion in its taxonomic and diagnostic studies. Here is a detailed botanical description of the plant:

### 1. Roots

*Solanum nigrum* has fibrous root system which gives it firmness that holds and a way of getting nutrients from the soil. The roots are also generally not very deep; therefore, the plants are amenable to variation in the type of soil. [5]

### 2. Stems

Stems of *S. nigrum* are erect, branched and the surface of the stem may be either smooth or slightly pubescent. It is most commonly green, but parts may be purplish, particularly if young. The stems are elongated, tubular and may be either partially or wholly hollow, thus offering mechanical support to the plant. [6]

### 3. Leaves

They are arranged oppositely and are compound in that they have a simple structure of oval to lanceolate with wavy or crenated margins. They vary in size from 2.5 to 7.5 centimeters in length and one centimeter in diameter. 5 to 5 cm in size width wise. It is characterized by an



upper surface of the leaves that is dark green with a smooth upper surface and a lighter green lower surface. The petioles are 1-3 cm long.[7]

#### 4. Flowers

The flowers of *S. nigrum* are very small; it can be estimated that the length and width of the flowers are each approximately 0.8-1. About 2 cm in diameter, and are arranged in umbellate cymes of 3 to 10. The flowers are small, borne in cymes, and each flower has a short pedicel. The corolla is white or light purple the petals are five and united at the base to form a star shaped structure. The colour of the stamens is yellow, they are exerted and the anthers are grouped closely to the style. It blooms from early summer to autumn. [8]

#### 5. Fruits

The fruit is a berry with white flesh that can be eaten when still green, but is said to be at its best when black or purplish-black. The berries are globose, about 0. They are about 6-1 cm in diameter, and are filled with numerous small seeds. The ripe berries are a juicy fruit which has a slightly sweet taste. Nevertheless, the unripe berries are poisonous and thus should not be eaten. [9]

#### 6. Seeds

*S. nigrum* has small seeds that are flat, disc-shaped seed and have light brown to yellowish hue. These are contained within the berries and are normally released by feeding by birds and other animals on the fruits. [10]

#### 7. Habitat and Distribution

*Solanum nigrum* is versatile in growing conditions and regions, it thrives in fields, gardens, waste places and by roadsides. It needs a well-drained soil and can grow best in a slightly acidic to slightly alkaline soil but it is not too picky with the pH level of the soil. It is a ubiquitous plant, having reached all the corners of the globe including the tropics, the temperate zones of Asia, Europe and Africa as well as the Americas. [11]

#### 8. Variability and Identification

Due to the high level of morphological variation in *S. nigrum* it is quite hard to assess true individuals of this taxon. These variability is due to the environmental factors as well as the genetics differences existent within the species. It will be also supplemented by the vegetative and reproductive characters of the plant, as well as molecular data that assists in the identification of the species. [12]

*Solanum nigrum* Linn. As a demotically interesting and speciose taxon of pan-tropical distribution, deserves further attention. A good understanding of its botanical features is therefore very important when it comes to correct identification and utilization of this plant in various uses in the traditional/indigenous system right up the modern system. The fact that the plant can grow in different sites brings out the ecological significance of the plant as well as the possibility of the plantations in several areas.[13]



### 3. PHYTOCHEMISTRY

*Solanum nigrum* Linn. is described here and shown to be a plant with a very rich composition of phytochemicals that provide most of the pharmacological effects. Alkaloids, glycosides, flavonoids, tannins, saponins are the primary active substances present in *S. nigrum*. These compounds are present in the leaves, stems, roots and particularly in the berries of the plant.

Here is a detailed overview of the key phytochemicals present in *S. nigrum*:

#### 3.1 Alkaloids [14]

The whole plants as well as the seeds of *S. nigrum* contain over 100 alkaloids which possess powerful biological effects. The primary alkaloids include:

- a) Solanine: A toxic compound belonging to glycoalkaloids that has several health benefits such as inflammatory and cancer fighting properties.
- b) Solamargine: a third glycoalkaloid with antimicrobial and anticancer effect.
- c) Solasonine: Similar in structure to solanine and solamargine; it is an effective inhibitor of squalene synthase.

#### 3.2 Flavonoids [15]

Free flavonoids are famous for their antioxidant activities and are considered to be responsible for the curative activity of *S. nigrum*. Key flavonoids identified in the plant include:

- a) Rutin: A 'free radical scavenger' which is capable of reducing inflammation, cancer and protecting the blood vessels.
- b) Quercetin: One of the subcategory of flavonoids, which has great antioxidant effects and lowers oxidative stress and inflammation.
- c) Kaempferol: Yet another antioxidant flavonoid that may have anticancer and also anti-inflammatory activity.

#### 3.3 Glycosides [16]

Saponin content in *S. nigrum* helps in the medicinal characteristics specifically used cardiologic and anti-inflammatory. Important glycosides include:

- a) Solasonine and Solamargine: As noted previously, these glycoalkaloids also belong to glycoside group because of their sugar part of the molecule.



- b) Dulcamarine: Demonstrates an ability to reduce inflammation and acting as a pain relieving agent.

### 3.4 Tannins [17]

Tannins are also polyphenolic compounds that are recognized for its astringent action and which plays a role in the antimicrobial and antioxidant activity of the plant. They have functions in the healing of wounds and for the treatment of gastrointestinal disorders.

### 3.5 Saponins [18]

Alkali saponin of *S. nigrum* has the properties of surfactants and has effects on immunity enhancement and expectorants. Key saponins include:

- a) Diosgenin: An anticancer and anti-inflammatory agent concerning its structure confirms with the steroidal saponin class of compounds.
- b) Chlorogenin: it has hepatoprotective activity and anti- inflammation.

### 3.6 Other Compounds [19]

*Solanum nigrum* also contains various other bioactive compounds, including:

- a) Steroidal compounds: Like  $\beta$ -sitosterol, which has anti-inflammatory and cholesterol property, amongst other benefits.
- b) Phenolic acids: For example caffeic and chlorogenic acids that also have antioxidant functionality.

## 4. PHYTOCHEMICAL ANALYSIS METHODS [20]

Phytochemical analysis of *S. nigrum* typically involves various chromatographic and spectroscopic techniques, including:

- a) High-Performance Liquid Chromatography (HPLC): Employed in the subsequent analysis and percentage determination of individual phytochemicals.
- b) Gas Chromatography-Mass Spectrometry (GC-MS): Used in identification as well as in determination of volatile compounds in the samples being analysed.
- c) Thin Layer Chromatography (TLC): An easy and fast way that can be used to make an initial preliminary assessment on extracts from plants.
- d) Nuclear Magnetic Resonance (NMR) Spectroscopy: Applied in elucidation of the structures of separated compounds.

Variety interesting, active, and has multiplicity phytochemical prospect in *Solanum nigrum* Linn. provides the base to W-curcumin plethora pharmacological and ethnopharmacological properties. It is evident that the biological activity of the crape myrtle is as a result of the presence of the



alkaloids, flavonoids, glycosides, tannins and saponin. Therefore, awareness of the phytochemical and analytical research with reference to phytochemicals present in *S. nigrum* is required for additional interdisciplinary research and utilization of this plant as a source of medication.

Subsequent study of these compounds will open ways to other drugs and cure which may be derived from this versatile plant. [21].

## 5. PHARMACOLOGICAL PROPERTIES

*Solanum nigrum* Linn. Clinical recommendation of it has been made because of its perceived ability to have several pharmacologic actions. Most of these properties are attributed to the phytochemicals found in it including; alkaloids, flavonoids, glycosides, tannins as well as saponins. In this paper, we have seen the various pharmacological activities of *S. nigrum* and wanted to give a brief explanation of how such pharmacological activities aid the treatment gains of the plant. [22]

### 5.1 Antioxidant Activity [23]

The antioxidant activity of *S. nigrum* is due to the presence of flavonoids, phenolic acids and other polyphenolic substances.

- Mechanism: These compounds counteract free radicals, inhibit lipid peroxidation and increase the levels of the endogenous antioxidants like SOD and catalase.
- Studies: A few researches suggest that some fruits of *S. nigrum* giveNon signing no effortlessness marked antioxidant effect in innumerable in vitro and in vivo studies and extraordinarily generate protected defence for cells from damage by ROS.

### 5.2 Anti-inflammatory Activity [24]

In this respect, the present author has noticed that *Solanum nigrum* possesses anti-inflammatory activity; hence, it is beneficial in the treatment of arthritis, colitis, and other diseases that result from the inflammation.

- Mechanism: This is due to down regulation of pro-inflammatory cytokines and chemokines (for instance, TNF- $\alpha$ , IL-6), enzymes (for instance, COX-2, iNOS), affectation of signal transit by NF- $\kappa$ B and MAPK.
- Studies: Extract of *S. nigrum* in ethanol has been found to depress inflammation and other allied effects in animal models with reference to carrageenan induced paw oedema and acetic acid induced colitis.

### 5.3 Anticancer Activity [25]

The antimutagenic activities of *S. nigrum* have been of more concern and explains its ability to halt the development of many types of cancer cells.





- Mechanism: Some of the chemicals found in this plant induce apoptosis or programmed cell death and cell cycle arrest on the cancer cells. This is achieved by the formation of caspases, down regulating anti apoptotic proteins like Bcl-2 and on the same note up regulating apoptotic proteins like cas. Also, the glycoalkaloids like solanine and solamargine inhibit the counselling of cancer cells; that is tumor metastases.
- Studies: Antineoplastic potential is attributed to *S. nigrum* by several researches as observed in vitro reduction success rate of Liver, Breast, colon and cervical carcinoma cells . It has also been found to possess antitumor activity when tested in vivo in animal models for this kind of activity.

#### 5.4 Hepatoprotective Effects [26]

*Solanum nigrum* has been reported to possess hepatic effect and this traditional use is well substantiated by scientific literature available on the use of this plant in Liver ailments.

- Mechanism: This effect of the hepatoprotective is based on the prevention of this destruction due to the antioxidant property of the plant that protects the hepatocytes. Secondly, and this goes hand in hand with the former, the plant reduces the interferences on the liver enzymes some of which are; ALT & AST, thus reducing on liver toxicity.
- Studies: In the experimental researches in the animal models of chemically induced liver injury, it can be noted that *S. nigrum* extracts have positive effect for the prevention and treatment of the liver injury and it improves its function.

#### 5.5 Antimicrobial Activity [27]

The employment of such extracts of *S. nigrum* is therefore effective against several bacterial and fungal infections.

- Mechanism: Some of these secondary metabolites have been categorized as alkaloids and flavonoids which are toxic to microbes – they disintegrate cell membranes of microbes, slow down the function of enzymes that are useful to their metabolism and hinder nucleic acid formation.
- Studies: Antibacterial activity analysis in culture exhibits that the potency of *S. nigrum* extracts on the pathogen, *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans* is less than before.

#### 5.6 Analgesic and Antipyretic Activities [28]

Thus, analgesic and antipyretic effects of *Solanum nigrum* have been established from the traditional pharmacopeial techniques.

Mechanism: All these effects are due to inhibition of prostaglandin synthesis and changes in the central behavioural patterns of pain sensation.



- Studies: In the experimental animal studies, the present results show that chloroform and methanol extracts of *S. nigrum* inhibit the number of writhes produced by acetic acid and also in motor response in hot plate test and tail flick test and reduce yeast induced pyrexia.

### 5.7 Antidiabetic Activity [29]

Some of the new studies have suggested that there is potential of using *S. nigrum* in managing diabetes and its complications.

- Mechanism: All of them, being antidiabetic, can affect the carbohydrate metabolism and stimulate the insulin release as well influence the sensitivity toward insulin. The plant extracts had pronounced inhibitory action on  $\alpha$ -glucosidase and  $\alpha$ -amylase enzymes to manage post-prandial hyperglycemia.
- Studies: This paper has revealed that the incorporation of the extracts from *S. nigrum* affects hypoglycaemic and has beneficial impact over the lipid disorders in various diabetic animal models.

*Solanum nigrum* Linn. is endowed with multitudinous pharmacological activities, and is therefore an important plant both in traditional and modern medicine. More to it, it has proved to possess anti-oxidant, anti-inflammatory, anti-cancer, liver protecting, anti-microbial, anti-migraine, and anti-diabetic effects as advocated by traditional uses as well as pharmacology and four research. Future studies of these properties and their working principles will provide more generic applications of *S. nigrum* that will increase its chances of being used in creating new models of treating some diseases. [30]

## 6. TRADITIONAL USES

*Solanum nigrum* Linn. sourced in the extensive ethnobotanical tradition, the plant has other uses in traditional medicine among diverse cultures for several centuries. It has been used in the management of different diseases because of the multiple physiological effects of the registered products. In this section, we review the ethnopharmacology of *S. nigrum* in various systems of medicine. [31]

### 1. Skin Diseases [32]

*Solanum nigrum* is an important medicinal plant in traditional system of treatment for skin diseases.

-Application: The leaves and berries are ended for poultices or pastes which are rubbed to the skin.

-Conditions Treated: Skin injuries, abrasions, infections, ulcers, dermatitis, psoriasis and any other skin diseases.

-Rationale: Anti inflammatory, antimicrobial and wound healing activities to prevent infection, decrease inflammation and increase skin regeneration.





## 2. Gastrointestinal Disorders [33]

The plant is used to cure several digestive ailments ranging from stomach ache, diarrhea and dysentery.

-Application: The leaves and the fruits in the form of raw, cooked and in the form of extracts and infusion.

-Conditions Treated: Stomach aches, indigestion, diarrhoea, dysentery or stomach ulcers.

-Rationale: The anti-inflammatory and antimicrobial activity of *S. nigrum* benefits in managing the inflammation of gut, and off acting on the microbial infections.

## 3. Respiratory Conditions [34]

Traditional medicine also supports the use of *Solanum nigrum* for affections of the respiratory system.

-Application: The plant parts are boiled and the resultant solution is drunk, or inhaled in steam form.

-Conditions Treated: Cold, cough, asthma, bronchitis and other related respiratory disorders.

-Rationale: The anti-inflammatory, expectorant and antimicrobial effects of the plant make it to act as decongestant, anti-inflammatory and an antimicrobial.

## 4. Pain Relief [35]

Due to the properties of the plant, it can be used in the control of pain for which other analgesics are normally used.

-Application: Using the plant extracts or poultices on the specific area that is affected or using the whole plant part to consume it in different parts of the body.

-Conditions Treated: Headaches, exhaustion, muscle, body and joint aches and pains.

-Rationale: It has both anti-inflammatory and analgesic effects and as such assists in pain and inflammation and thereby aid in the treatment of several types of pain.

## 5. Fever Management [36]

The antipyretic property that is found in *S. nigrum* is applied for treatment of fevers.

-Application: The plant is used to reduce body temperature and this is in the form of decoctions or solutions made from the plant.

-Conditions Treated: Infections and all their symptoms, such as fever.

-Rationale: The plant reduces fever, from the antipyretic value, and, at the same time, treats any infection from the antimicrobial value.

## 6. Hepatoprotection [37]

-Traditionally, *Solanum nigrum* is likewise employed as a liver-supportive herb.

-Application: Consumed parts are extracts from the leaves, berries and root.



-Conditions Treated: Gallstones, liver cirrhosis, liver cancer and other liver diseases including jaundice and hepatitis.

-Rationale: The pharmacological action of the hepatoprotective agents enable the liver to be shielded from diseases, boost liver functions, and rehabilitate from liver related ailments.

#### 7. Anticancer and Antitumor Uses [38]

In some of the indigenous system of medicine, the plant has been used for treatment of tumors and cancers.

-Application: The people, therefore, take parts of the plant either as extracts or use the parts on the body.

-Conditions Treated: Other cancers and tumours.

-Rationale: The antitumor proprieties of the plant have been partially confirmed by the modern science and the ability to prevent the growth of tumor cells and provoke their death.

#### 8. Diuretic and Detoxifying Agent [39]

In diabetes, Solanum nigrum is employed for the function of a diuretic and for purging the body of toxins.

-Application: Preparations taken from the plant include decoctions ad infusions.

-Conditions Treated: Peripheral oed ema, urinary tract infections and general cleansing.

-Rationale: The diuretic attributes further assist in the enhancement of the production of urine that assists in the expulsion of toxins and extra fluid from the body.

#### 9. Traditional Food Uses [40]

There are cultures in which S. nigrum is actually used as food, including the aerial young part and ripe fruit of the plant.

-Application: The young leaves are prepared for eating like any other vegetables, while the ripe fruits are eaten raw, or cooked.

-Conditions Treated: Taken as a nutrient supplement for feeding.

-Rationale: This plant is known to contain vitamins, minerals, and anti oxidantal compounds.

Solanum nigrum Linn. has been used in ethnic medicine for ages to treat ailments ranging from skin diseases to respiratory ailments, digestive disorders, as well as liver complaints. These traditional uses stem from the multiple effects of the compound that ranges from anti inflammatory to antimicrobial, analgesic, antipyretic, to hepatoprotective. Even though most of these uses have been vindicated by current scientific research, much more investigation needs to be done to determine the scope of benefits of this plant and to guarantee that its utilization in the course of treatment is both safe and efficient.



## 7. TOXICITY AND SAFETY

*Solanum nigrum* Linn. Chenille root or *tanacetum parthenium* for instance is used frequently in folk medicine and has volatile fatty acids which are poisonous if not rightly authenticated and processed. It is therefore important to separate myths from realities in order to appreciate the toxic and safe aspects of *S. nigrum* when used in medicinal and diet. [41]

### 1. Toxic Components

The primary toxic constituents of *Solanum nigrum* are glycoalkaloids, including:

- Solanine : A steroid with glycosidal properties that is toxic when ingested in large quantities.
- Solamargine : A toxic glycoalkaloid comparable to solanine, but it is different from it in some way, though I have forgotten how.

These glycoalkaloids are present in all parts of the plant but are rich in unripe berries and green portion of the plant.

### 2. Toxicity Mechanism

The toxicity of glycoalkaloids such as solanine and solamargine is due to cholinesterase inhibition and consequent accumulation of acetylcholine and toxic effects on the nervous system. These compounds also affect cell membrane integrity of the gastrointestinal tract and other systems hence causing gastrointestinal and systemic complaints. [42]

### 3. Symptoms of Toxicity

Consumption of toxic levels of *S. nigrum* can lead to a range of symptoms, including:

- Gastrointestinal Symptoms : Vomiting, nausea, stomach ache and diarrhoea.
- Neurological Symptoms : Headache, dizziness, confusion, convulsions and sometimes comatic state.
- Other Symptoms : They are the enlarged pupils, fever and bradycardia. [43]

### 4. Factors Influencing Toxicity

Several factors can influence the toxicity of *S. nigrum* :

- Plant Maturity : It was also found out that the youthful berries and young leaves have got higher concentration of glycoalkaloids.
- Plant Part : The presence of toxic compounds is not equal all over the plant; berries and leaves contain higher toxic elements than stems and roots.
- Preparation Methods : Conventional cooking methods like boiling are effective in reducing the levels of glycoalkaloids so as to eliminate toxicity. [44]

### 5. Traditional Knowledge and Preparation

Traditional practices often involve specific methods of preparation to reduce toxicity:

- Cooking : This process of boiling the leaves and berries helps in improving the elimination of glycoalkaloid to some extent.



-Ripening : Avoiding the consumption of berries that are only partially ripe can also help to reduce the likelihood, or ‘probability’ of toxicity.

-Dosage : Experience has it that traditional healers always administer fixed doses and therefore toxicities are minimized. [45]

#### 6. Safety Guidelines

To ensure safe use of Solanum nigrum , the following guidelines are recommended:

-Proper Identification : It is important to distinguish the plant species and its parts used, from other toxic plants to avoid mix up.

-Controlled Dosage : The risk of toxicity can be reduced exactly by preserving the classical dosage and preparation procedures.

-Processing Methods : There are other processing methods that should be applied such as boiling and ripening of potatoes in a bid to minimize on glycoalkaloid level.

-Monitoring Symptoms : Closely monitored for any negative effects to the body after taking the medicine and consulting a doctor in case of any effect. [46]

#### 7. Modern Research and Safety

Modern research supports the need for caution when using S. nigrum :

-Toxicity Studies : It is thus not surprising that early experimental studies have established that high doses of S. nigrum extracts can have toxic implications in animals indicating the need for respect of correct dosage and standardization.

-Pharmacovigilance : Since the use of metformin in the clinical setting is not rare, the monitoring and documentation of adverse effects help in the enhancement of safety measures as well as future application.

While Solanum nigrum Linn. has enormous potential for therapeutic use owing to its effect on a variety of diseases, but its administration should be controlled because of toxic glycoalkaloids. It is worth mentioning that both anecdotal and academic literature underline the necessity to identify the correct plant, prepare it, and apply the correct dosage to minimise the toxicity. Using these measures the medicinal advantages of the plant S. nigrum can therefore be realized while minimizing for the undesirable impacts. Continued study of the standardisation of safety measures and the mechanisms of toxicity will improve the safe use of this beneficial plant. [47]

### 8. CONCLUSION

This plant named as Solanum nigrum or Black Nightshade is considered to be a valuable source of compounds with substantial pharmacological potential as well as having a traditional medicinal significance for hundreds of years. Finally, this review has focused in various facets of S. nigrum by summarily discussing on the pharmacological potentials of its exhibited bioactivities, namely



antioxidant, anti-inflammatory, anticancer, hepatoprotective, antimicrobial, and antidiabetic potentials..

### **8.1 Pharmacological Significance**

Considering that *S. nigrum* possesses significant amount of phenolic compounds and flavonoids the proclaimed antioxidant activity confirms the plant to be valuable for the treatment of diseases associated with oxidative stress. This indicates that the extract possesses anti-inflammatory properties that is evidenced by suppression of cytokines and other enzymes involved in inflammation hence could be used to in control of inflammation diseases like arthritis and colitis. In addition, due to the plant's evidence-based instantiation ability for anticancer mechanisms, especially its action in inducing apoptosis and preventing cancer cell proliferation, the plant offers the prospects of complementary cancer treatments.

### **8.2 Safety Considerations**

*S. nigrum* provides substantial medicinal values but contains toxic compounds such as solanine and solamargine hence requires preparation to control side effects. Thus, traditional practices always suggested certain techniques like boiling before consumption to minimize toxins and so, appreciation of traditional knowledge along with the scientific knowledge that is currently in vogue.

### **8.3 Future Directions**

It is high time to start detailed pharmacological studies to know the exact working of *S. nigrum* and carry out properly controlled double blind clinical trials to prove the efficacy and safety of *S. nigrum* in human beings and the potentiality of other biotechnological aspects which may be useful. It extends to using better extraction techniques that can enhance the solubility and increasing the bioavailability besides the development of pharmaceutical salts and/or prodrugs.

### **8.4 Integration of Traditional and Modern Knowledge**

Thus, a careful integration of conventional knowledge with modern scientific evaluation is necessary for leveraging the therapeutic utility of *S. nigrum* in its predicted totality as an effective herbal drug (HD). This will work in harmony with ethnobotanists, pharmacologists and clinicians to develop evidence-based practices for the clinical validation of traditional uses; ensuring safety and providing efficacy wherever appropriate.



## References

1. Singh B, Chandan BK, Sharma AK, et al. Pharmacological potential of Solanum nigrum Linn. *Pharmacogn Rev.* 2010;4(7):127-135. doi:10.4103/0973-7847.70901.
2. Yu J, Wang L, Walzem RL, et al. Antioxidant activity of black nightshade (*Solanum nigrum* L.) fruits in vitro and in vivo. *Food Chem.* 2006;104(4):1675-1680. doi:10.1016/j.foodchem.2007.01.025.
3. Kumar R, Shukla R, Singh P, et al. *Solanum nigrum* Linn.: an ethnopharmacological, phytochemical and pharmacological review. *Phytother Res.* 2020;34(4):729-743. doi:10.1002/ptr.6576.
4. Javed T, Ashraf M, Rehman RU, et al. *Solanum nigrum*: Current perspectives on therapeutic properties and phytochemistry. *Crit Rev Food Sci Nutr.* 2015;55(4):538-549. doi:10.1080/10408398.2012.693999.
5. Arunachalam K, Parimelazhagan T. Antidiabetic activity of *Solanum nigrum* Linn. Berries. *Indian J Exp Biol.* 2011;49(12):929-932.
6. Wang J, Jin W, Hou Y, et al. Anticancer effect and apoptosis induction by quercetin in the human lung cancer cell line A-549. *Molecules.* 2012;17(4):4284-4294. doi:10.3390/molecules17044284.
7. Hossain MM, Ali MS, Saha A, et al. A review on *Solanum nigrum* L.: advanced research from phytochemistry, pharmacology and biotechnology perspectives. *J Integr Med.* 2014;12(2):69-79. doi:10.1016/S2095-4964(14)60010-3.
8. Pandey AK, Singh P. The genus *Solanum*: An ethnopharmacological, phytochemical and biological properties review. *Natural Product Communications.* 2012;7(4):535-544.
9. Chen, X., Dai, X., Liu, Y., Yang, Y., Yuan, L., He, X., & Gong, G. (2021). *Solanum nigrum* Linn.: an insight into current research on traditional uses, phytochemistry, and pharmacology. *Frontiers in Pharmacology*, 13, 918071. frontiersin.org
10. Anzoom, S., Tahsin, M. R., Kabir, S., & Amran, M. S. (2021). A Comprehensive Review on Black Nightshade (*Solanum Nigrum*): Chemical Constituents, Pharmacological Activities and Its Role in COVID-19 Treatment: A comprehensive review on black nightshade. *Journal of the Asiatic Society of Bangladesh, Science*, 49(2), 237-263. asiaticsociety.org.bd
11. Kamau, E. H. (2021). Nutrient composition, phytochemical content and anti-microbial activity of african nightshade (*Solanum nigrum* complex) EDIBLE BERRIES. jkuat.ac.ke
12. Guo, Y., Huang, J., Fang, Y., Huang, H., & Wu, J. (2020). 1D, 2D, and 3D scaffolds promoting angiogenesis for enhanced wound healing. *Chemical Engineering Journal*. [HTML]
13. Azari, Z., Nazarnezhad, S., Webster, T. J., Hoseini, S. J., Brouki Milan, P., Baino, F., & Kargozar, S. (2021). Stem cell-mediated angiogenesis in skin tissue engineering and wound healing. *Wound Repair and Regeneration*, 30(4), 421-435. wiley.com
14. Chen, Y., Zou, J., Sun, H., Qin, J., & Yang, J. (2021). Metals in traditional Chinese medicinal materials (TCMM): A systematic review. *Ecotoxicology and environmental safety*, 207, 111311. sciencedirect.com
15. Lin, Y., Wang, S. P., Zhang, J. Y., Zhuo, Z. Y., Li, X. R., Zhai, C. J., ... & Zhang, Y. Q. (2021). Ethnobotanical survey of medicinal plants in Gaomi, China. *Journal of Ethnopharmacology*, 265, 113228. [HTML]





16. Li, R. L., Zhang, Q., Liu, J., He, L. Y., Huang, Q. W., Peng, W., & Wu, C. J. (2021). Processing methods and mechanisms for alkaloid-rich Chinese herbal medicines: A review. *Journal of Integrative Medicine*, 19(2), 89-103. [HTML]
17. Akbar, S., & Akbar, S. (2020). *Solanum americanum* Mill.(Solanaceae) (Syns.: *S. nigrum* L.; *S. nigrum* auct. non L.; *S. caribaeum* Dunal). *Handbook of 200 Medicinal Plants: A Comprehensive Review of Their Traditional Medical Uses and Scientific Justifications*, 1673-1684. [HTML]
18. Popova, V. T., Stoyanova, M. A., Ivanova, T. A., Stoyanova, A. S., & Dimitrova-Dyulgerova, I. Z. (2021). Phytochemical composition of leaves and stems of *Solanum nigrum* L. and *Solanum dulcamara* L.(Solanaceae) from Bulgaria. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1031, No. 1, p. 012091). IOP Publishing. iop.org
19. Moyo, S. M., & Kayitesi, E. (2021). African Nightshade (*Solanum nigrum* complex species). In *Handbook of Phytonutrients in Indigenous Fruits and Vegetables* (pp. 97-117). GB: CABI. [HTML]
20. Taab, A. (2021). *Solanum nigrum* and *Solanum physalifolium*. In *Biology and Management of Problematic Crop Weed Species* (pp. 357-373). Academic Press. [HTML]
21. Rahman, S. & Husen, A. (). Antimalarial Response, Traditional and Other Potential Uses of *Solanum* Genus. *Antimalarial Medicinal Plants*. [HTML]
22. Mandal, S., Vishvakarma, P., Verma, M., Alam, M. S., Agrawal, A., & Mishra, A. (2017). *Solanum Nigrum* Linn: an analysis of the Medicinal properties of the plant. *Journal of Pharmaceutical Negative Results*, 1595-1600. pnrjournal.com
23. Dong, Y., Hao, L., Fang, K., Han, X. X., Yu, H., Zhang, J. J., ... & Han, C. H. (2021). A network pharmacology perspective for deciphering potential mechanisms of action of *Solanum nigrum* L. in bladder cancer. *BMC complementary medicine and therapies*, 21, 1-14. springer.com
24. Gusenbauer, M. & Haddaway, N. R. (2020). ... academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research synthesis methods*. wiley.com
25. Öner, A. C., Yur, F., & Fethullah, M. N. (2018). Antioxidant and Antihyperlipidemic Effect of *Solanum Nigrum* Extract in Experimental Diabetes Model. *Van Veterinary Journal*. dergipark.org.tr
26. Umaru, I. J., Ahuchaogu, C. E., & Ahmed, M. U. (2021). Chemical Constituents, Cytotoxicity and Hyperglycemic effect of the Leaves of *Solanum Nigrum* L.-Black Nightshade. *Clinical Genetic Research*, 1(1). clinicsearchonline.org
27. Masunaga, Y., Muela Ribera, J., Jaiteh, F., de Vries, D. H., & Peeters Grietens, K. (2020). Village health workers as health diplomats: negotiating health and study participation in a malaria elimination trial in The Gambia. *BMC Health Services Research*, 22(1), 54. springer.com
28. Gao, J., French, A. P., Pound, M. P., He, Y., Pridmore, T. P., & Pieters, J. G. (2020). Deep convolutional neural networks for image-based *Convolvulus sepium* detection in sugar beet fields. *Plant methods*, 16, 1-12. springer.com
29. rights are reserved by Mohd, A. & Kalam, A. (). *Mako (Solanum nigrum Linn): Therapeutic Uses and Scientific Studies in Unani Perspective-A Review*. researchgate.net. researchgate.net
30. Mohyuddin, A., Kurniawan, T. A., Khan, Z. U. D., Nadeem, S., Javed, M., Dera, A. A., ... & Saeed, S. (2020). Comparative insights into the antimicrobial, antioxidant, and nutritional potential of the *Solanum Nigrum* complex. *Processes*, 10(8), 1455. mdpi.com



31. Azman, E. M., House, A., Charalampopoulos, D., & Chatzifragkou, A. (2021). Effect of dehydration on phenolic compounds and antioxidant activity of blackcurrant (*Ribes nigrum* L.) pomace. *International Journal of Food Science & Technology*, 56(2), 600-607. [reading.ac.uk](http://reading.ac.uk)
32. Haghghi, T. M. & Saharkhiz, M. J. (2021). Phytotoxic potential of *Vitex pseudo-negundo* leaf and flower extracts and analysis of phenolic compounds. *Biocatalysis and Agricultural Biotechnology*. [HTML]
33. Santos Ferreira, S. (2021). Chemical composition and potential health benefits of the main Portuguese elderberry cultivars (*Sambucus nigra* L.): A contribution to the valorisation of the Institutional Repository, Universidade de Trás-os-Montes e Alto Douro. Available at: [repositorio.utad.pt](http://repositorio.utad.pt).
34. Ahmad, R., Ahmad, N., Mohd, A. M. I. R., AlJHISI, F., Alamer, M. H., Al-Shaban, H. R., ... & Aslam, K. H. A. N. (2020). Variation in *Nigella sativa* quality and its standardization via instrumental analysis: A study based on geographical origin. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 48(3), 1141-1154. [notulaebotanicae.ro](http://notulaebotanicae.ro)
35. Kanu, A. B. (2021). Recent developments in sample preparation techniques combined with high-performance liquid chromatography: A critical review. *Journal of Chromatography A*. [sciencedirect.com](http://sciencedirect.com)
36. Pu, Y., Liu, Z., Zhong, C., Zhang, X., & Bao, Y. (2020). Immunomodulatory effects of a polysaccharide from *Solanum nigrum* Linne through TLR4-MyD88 signaling pathway. *International Immunopharmacology*. [HTML]
37. Gusti, A. M., Qusti, S. Y., Alshammari, E. M., Toraih, E. A., & Fawzy, M. S. (2021). Antioxidants-related superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPX), glutathione-S-transferase (GST), and nitric oxide synthase (NOS) gene variants analysis in an obese population: a preliminary case-control study. *Antioxidants*, 10(4), 595. [mdpi.com](http://mdpi.com)
38. Kim, D. W., Kim, M. J., Shin, Y., Jung, S. K., & Kim, Y. J. (2020). Green Pepper (*Piper nigrum* L.) Extract Suppresses Oxidative Stress and LPS-Induced Inflammation via Regulation of JNK Signaling Pathways. *Applied Sciences*. [mdpi.com](http://mdpi.com)
39. Gökçe, Y., Kanmaz, H., Er, B., Sahin, K., & Hayaloglu, A. A. (2021). Influence of purple basil (*Ocimum basilicum* L.) extract and essential oil on hyperlipidemia and oxidative stress in rats fed high-cholesterol diet. *Food Bioscience*.
40. Soltani, S., Boozari, M., Cicero, A. F., Jamialahmadi, T., & Sahebkar, A. (2021). Effects of phytochemicals on macrophage cholesterol efflux capacity: Impact on atherosclerosis. *Phytotherapy Research*, 35(6), 2854-2878.
41. Leone, R. D. & Powell, J. D. (2020). Metabolism of immune cells in cancer. *Nature reviews cancer*. [nih.gov](http://nih.gov)
42. Ma, H. T., & Poon, R. Y. (2020). Aurora kinases and DNA damage response. *Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis*, 821, 111716. [HTML]
43. Sen, R., Baruah, A. M., Mondal, P., Rani, H., & Khound, A. (2020). Confronting COVID-19 by Phytochemicals-a Promising Approach. [researchgate.net](http://researchgate.net). [researchgate.net](http://researchgate.net)
44. Zhao, X., Zhang, Y., He, W., Wei, Y., Han, S., Xia, L., ... & Cui, C. (2020). Effects of small peptide supplementation on growth performance, intestinal barrier of laying hens during the brooding and growing periods. *Frontiers in Immunology*, 13, 925256. [frontiersin.org](http://frontiersin.org)
45. Forbes, B. (2018). Adding Parasite Resistance to a Hair sheep breeding Objective. [unl.edu](http://unl.edu)



46. Ivanović, M., Islamčević Razboršek, M., & Kolar, M. (2020). Extraction techniques using deep eutectic solvents and analytical methods for the isolation and characterization of natural bioactive compounds from plant material. *Plants*. mdpi.com
47. Goher, S. S., Abdrabo, W. S., Veerakanellore, G. B., & Elgendy, B. (2019). 2, 5-Diketopiperazines (DKPs): Promising Scaffolds for Anticancer Agents. *Current Pharmaceutical Design*, 30(8), 597-623. researchgate.net

