J. Plant Environ. 05 (02) 2023. 181-189 DOI: 10.33687/jpe.005.02.4576

Available Online at EScience Press
Journal of Plant and Environment
ISSN: 2710-1665 (Online), 2710-1657 (Print)
https://esciencepress.net/journals/JPE

Medicinal Importance of *Solanum nigrum* Linn; A Review

Ali Zeeshan[1*], Waheed Amjad[1], Sidra Faiz[2], Mohsin Noor[3], Waseem Akram[3], Iqra Yameen[3], Horia Hassan[1], Kainat Majeed[1]

[1] *Department of Biological Sciences, University of Veterinary and Animal Sciences, Lahore, Punjab, Pakistan.*
[2] *Department of Botany Government College University Faisalabad, Pakistan.*
[3] *Department of Wildlife and Ecology University of Veterinary and Animal Sciences Lahore, Punjab, Pakistan.*

ARTICLE INFO

Article History
Received: August 28, 2023
Revised: October 15, 2023
Accepted: October 21, 2023

Keywords
Solanum nigrum
Antioxidant activity
Antiproliferative
Antifungal
Antistress effect

ABSTRACT

Solanum nigrum (Black nightshade) is an indigenous medicinal plant that has been utilized in traditional medical systems for ages. *S. nigrum* includes bioactive substances such as alkaloids, flavonoids, steroids, and saponins, according to phytochemical research. Extracts and isolated chemicals indicate antioxidant, anti-inflammatory, antibacterial, antifungal, anti-diabetic, anti-cancer, immune-stimulating, therapeutic, and heart-protective effects. *S. nigrum* extracts, in particular, limit cancer cell growth, minimize chemically induced organ damage, alter immunological function, and provide protection against oxidative stress, according to animal and cell culture studies. *S. nigrum* has traditionally been used for the prevention of symptoms such as discomfort, inflammation, infections, and problems with the gastrointestinal tract. Overall, this comprehensive study reveals the varied therapeutic qualities of *S. nigrum* that demand further exploration.

Corresponding Author: Ali Zeeshan
Email: alizeeshan4245@gmail.com

INTRODUCTION

Plant-based medicines have been used in folkloric medicine by humans for many years (Bin *et al*., 2017). The genus *Solanum* has over 2,000 different tropical and subtropical perennials that are thought to be found in all tropical and subtropical regions of the planet. Ganake soppu in Kannada, Makoi in Hindi, Kachchipandu in Telugu, Munatakali in Tamil, Piludi in Gujarati, and Black Night Shade in English are all names for the plant *S. nigrum* Linn. In addition to these names, this species of plant is also known as Ganake soppu and Kamuni in Kannada. Locally, medicinal plants are used to cure diseases caused by fungus, bacteria, viruses, and parasites. Furthermore, nearly 60 % of individuals in rural regions rely on traditional medicine to address their problems. Various plants have been utilized as inspiration for the creation of new medications. Plant-based medications are commonly utilized because they are safer than synthetic counterparts and are more readily available and less expensive. Secondary metabolites are the active ingredients of many medicines discovered in plants (Kumar *et al*., 2020). The annual shrub-like black nightshade has a limited life period. It might be anywhere amongst shades of green and purple at times. Its hairs will be free of prickles, whether follicular or uncomplicated and non-glandular. Because of its antibacterial and antidysentery properties, the "plant" has been employed domestically in India to treat ailments such as cardialgia and gripe. Furthermore, the "plant" is widely recognized for its antibacterial properties. The *S. nigrum* plant has a variety of medicinal properties notably anti-oxidative, anti-cancerous, detoxifying, neurological-protective, and antiulcerogenic properties.

Current rat studies looked at the possible oxidative damage caused by CCL4 as well as the potential preventive benefits of an oral extract of the leaves of the *S. nigrum* plant (Rani *et al*., 2017). *S. nigrum* Linn. Belongs to Solanaceae family the plant used to cure a variety of infectious diseases that can affect people (Mandal *et al*., 2023). *S. nigrum*, which is additionally known as black night shade, biosynthesizes a variety of bioactive chemicals with a variety of therapeutic effects, including the treatment of cardiovascular illnesses and type 2 diabetes, among others (Nderitu *et al*., 2023). *S. nigrum* has traditionally been used to treat a variety of maladies including discomfort, eczema, hay fever, and gastrointestinal infections (Rani *et al*., 2004). It is also used in the treatment of sexually transmitted illnesses (Atanu *et al*., 2011). *S. nigrum* has been repeatedly employed in conventional medical practices throughout history for its possible therapeutic effects. The plant has been used to cure a variety of diseases, particularly allergic reactions, dermatitis, gastrointestinal problems, and asthma. It has previously been administered as aphrodisiacs and for pain relief (Pandey *et al*., 2021).

Macroscopy

The wood is light yellow and can be seen through the thin, easily peeled bark. The blooms are typically symmetrical and have five petals. They can be flat and round or star-shaped, although they're more frequently bell or tubular shaped. Plants in this family frequently have hairy stems and leaves and are jumpers or at best clinging plants. The leaves are frequently interspersed, entire, or split, and without septat. The root is outwardly smooth and pale brown, with only a few projections and numerous little lateral roots, according to the morphological analysis. Fruit pulp has free-lying seeds and displays a narrow, spongy texture modules, fruity endosperm, and barrel anovulation. The fruits are berries, often oblique and 6mm in diameter (Jani *et al*., 2012).

Microscopy

Uni seriate trichomes with hooked points that cover the twig and rachis of the leaf exhibit an arc-shaped organization of secondary vascular tissue. Anisocytic stomata can be seen on the lamina of the leaf, albeit they seem to be more prevalent on the lower side. Ratio of the palisade: 2-4 and number of vein islets: 7-10 (Jani *et al*., 2012).

Phytochemicals from *S. nigrum*

The entire plant has coumarins, phytosterols, proteins, carbohydrates, tannins, flavonoids, and glycosides, according to a phytochemical investigation. Glycoprotein, steroidal saponins, and steroid alkaloids, all of which have been verified to be present in *S. nigrum*, have been shown to contain chemicals with anti-tumor effect. A study looked at the chemical composition of an osmotin like protein from this plant (Jami *et al*., 2007). This plant has created a novel glycoprotein (150 KDa) that is over 50% polar amino acids include glycine and proline and is predominantly made of carbohydrates (69.74%) and proteins (30.26%) (Lee and Lim, 2003) *S. nigrum's* tiny, immature fruits had high levels of solasodine, but as they develop, both the proportion and the total amount per fruit decrease. According to some experts, the species of *S. nigrum* generate acetic acid, however it is more abundant in the berry than the root (Kapoor *et al*., 2004). Six new intravenous testosterone saponins (solanigrosides C-H), also known as glycosides (degalactotigonin), were discovered from the complete *S. nigrum* plant (Zhou *et al.,* 2006). Researchers have isolated four saponins from the complete *S. nigrum* plant, including two new steroidal saponins classified as *nigrum*nins I and II as well as two existing recognized saponins. (Ikeda *et al*., 2000) As a result, employing phytochemical research, two novel sugars were extracted from *S. nigrum*. Their structures were determined to be ethyl b- D-thevetopyranosyl-(1-4)- b- D-oleandropyranoside and ethyl b-D-thevetopyranosyl-(1-4)- a-D-oleandropyranoside, respectively, using chemical and spectroscopic methods. *S. nigrum* seeds have a high lipid content. They are an excellent source of protein, minerals, especially magnesium as the most prominent, and linoleic acid, which is a major component of *S. nigrum* oil. (Dhellot *et al*., 2006).

Pharmacology of *S. nigrum* Linn

Numerous studies shown that *S. nigrum* infusions acted as a cytoprotective agent against gentamicin-induced Vero cell damage in addition to acting as an anti-neoplastic agent against Sarcoma 180 in rodents, inhibiting oxidant-mediated DNA sugar damage.

Recent research discovered that *S. nigrum* focuses had a detrimental effect on binding protein 13-acetate (TPA)-mediated tumor promotion in HCT-116 cells and that methanolic extracts of fresh fruits had an outstanding anticarcinogenic effect against caused liver damage. The aqueous extract of *S. nigrum* contains several antioxidants, including cinnamic acid, PCA, catechin, carnosic acid, epicatechin, rutin, and narigenin, and exhibits considerable cellular antioxidant activity in vitro

(Chou *et al*., 2008). On laboratory animals, the biological effects of an ethanol extract of the fruit of *S. nigrum* were explored. The extract also altered general behavioral patterns, decreased exploratory behavior patterns, suppressed violent conduct, changed higher levels of activity, and reduced spontaneous movement by prolonging pentobarbital-induced sleep duration after intraperitoneal administration. This hepatoprotective function may be attributed to the herb's ability to control purifying proteins, as well as its oxidative and free radical-scavenging properties (Chou *et al*., 2008).

Previous research has shown that lowering transforming growth factor (TGF)-1 release can reduce hepatic fibrosis in rats. In several studies, a glycoprotein from *S. nigrum* was found to exhibit high anti-reactive oxygen radical scavenging or growth-inhibiting properties against JA221 and XL1-Blue. Furthermore, MCF-7 and HT-29 cells have been shown to be cytotoxic to amino acids, even when exposed to low concentrations. Inhibiting systemic HMG-CoA reductase in rats improves the activity of decontaminating enzymes and has considerable anti-lipid per oxide radical and hypolipidemic effects through glycoprotein (Heo *et al*., 2004; Lim *et al*., 2004; Lee *et al*., 2005). According to research, MCF-7 cells degrade proteins. According to (Lee and Lim, 2003; Son *et al.*, 2003), the methanol extract exhibits lethal, necrotic, and anti-proliferative adverse effects on MCF-7 cells. In HCT-116 cells, glycoprotein induces apoptosis by activating NF- and producing inhibiting nitric oxide (iNO) (Lee and Lim, 2003). TPA-induced DNA-binding activities of gene transcription factors and NO interpreting, both of which are important for MCF-7 cell anticancer activity, can be altered by glycoprotein. As a consequence, a glycoprotein derived from *S. nigrum* may be one chemical that inhibits the production of TPA signal pathways in cancer cells (Heo *et al.,* 2004).

On Vero cells, the ability of a 50% alcoholic extract of the whole *S. nigrum* plant to cytoprotect against gentamicin-induced toxicity was evaluated in vitro. Both the mitochondrial enzyme production (MTT) and the Trypan Blue Exemption Examination demonstrated a considerable reduction in cytotoxicity. Furthermore, the study decoction had shown a substantial ability to neutralize hydroxyl radicals, demonstrating a potential cause of cell harm (Kumar et al., 2004). Previous research found that treating rats with *S. nigrum* fruit has antiulcer, antioxidant, and tumor-stimulating effects (Jainu and Devi, 2004). The intravenous of *S. nigrum*, which exhibited considerable antibacterial activity without any clear toxicological consequences, lends evidence to *S. nigrum*'s efficacy in Indian ayurvedic medicines for stomach treatment. While both ulcer-preventing and ulcer-healing capabilities of *S. nigrum* may be attributed to an ant secretory effect, the antisecretory activity tends to be principally associated with the inhibition of H+K+ATPase and the decrease of secretion release (Jainu and Devi, 2006). The antioxidant ability of *S. nigrum* leaf extract was evaluated using the management of restraint-induced oxidative stress. Crude extract used after treatment was shown to be more effective than prophylaxis at reversing the oxidative alterations caused by immobilization stress in rat plasma. Infusion of *S. nigrum* can be administered as a preventative and restorative treatment for removing free radicals in order to reduce oxidative stress, which is evident in many clinical illnesses (Al-Qirim *et al*., 2008). The antimicrobial capacity of the isolated proteins was tested using DPPH, hydroxyl radical, and hydroperoxyl tests. Based on these findings, it has been demonstrated that glycoprotein has significant antioxidative potential (Heo and Lim, 2004). It has also been reported that *S. nigrum* fruit extracts have potent rate of mortality, anti-inflammatory, and soothing qualities (Ravi *et al*., 2009).

Antiproliferative activity/cancer preventive

On many cancer cell lines, *S. nigrum's* chloroform extract and separated constituents both have antiproliferative properties. The antiproliferative properties of the raw organic extricate and separated components were examined on tumor cell lines of the liver. Although it may be produced from the complete plant, crude extract is frequently produced with dried fruits. (HepG2) (Ji *et al*., 2008; Lee *et al*., 2004) (HT29 and HCT-116) (Ji *et al*., 2008), Breast (Lee et al., 2004) (MCF-7), cervical cancer (Li *et al*., 2009) (U1424, 25 and HeLa27). The antimutagenic activity of these fractions was examined by examining the toxicity of the isolate on cells. DNA fragmentation, a sign of apoptosis, was used to analyses the extent of cell death in the treated cells. Apoptosis, commonly known as "programmed cell death," is mediated by two routes. Hepatocytes are necessary for the intrinsic mechanism to work, but death receptors initiate the exogenous pathway. Known to control apoptosis at the mitochondria are the antiapoptotic (Bcl-XL, Bcl-2, and Mcl-1) and antitumor activity (Bax, Bak, Bid, Bim, and Bad) proteins. Crude extracts at medium and high concentrations have been demonstrated to

trigger a variety of responses in cells in in vitro experiments. When liver tumor cell lines (HepG2) are exposed to large amounts of the crude extract, c-Jun N-terminal kinase (JNK) is activated, which results in the stimulation of antiapoptotic proteins like Bax. Furthermore, it results in the mitochondrial release of cytochrome C, which activates caspases and starts the apoptotic process. An additional (Glossman *et al*., 2003) Autophagy, as opposed to apoptosis, is brought on if the same hepatocytes are treated to small amounts of extracts (Sikdar and Dutta, 2008). The cell's defective vesicles or malfunctioning route get it ready to adapt to challenging conditions through autophagy, a lysosomal destruction mechanism. This may help to explain why a minimal quantity results in apoptotic cell death (Oh and Lim, 2007). The anti-cancer effect of hydrophilic plant extracts is demonstrated by the prevention of cervical carcinoma growth. The mechanisms of action of isolated polysaccharides (SNL-P) and aqueous extracts (Joo *et al.,* 2009) were shown to be comparable (Joo *et al*., 2009).

Polysaccharides are most likely the active components in antioxidant activities that have an anticancer potential, as according to (Li *et al*., 2008). SNL-P demonstrated no cytotoxic effects on U14 bioreactors produced from cancer. Its anticancer activities are caused by its immunomodulatory traits, which alter the host's immune response. (Li *et al*., 2008) is crucial since chemotherapy exacerbates the defense system's already compromised condition as cancer advances. By stopping these units in the G2/M phase, the SNL-P treatment developed by (Tournier *et al*., 2000) increases the fraction of CD-4+ lymphocytes. According to (Li *et al*., 2008) Immunotherapy (IFN-) predominantly stimulates T-helper 1 cells, whereas SNL-P promoted CD_4+ cells. -1 cells support the fight against intracellular infections as well as the eradication of self-modified or premalignant (Mumberg et al., 1999; Mumberg and Lodge 1998). A genital disease in mice, SNL-P has been demonstrated to exhibit significant immunomodulatory and anticancer actions (Li *et al*., 2008).

Antioxidant activity/degenerative disease; anti-aging

Exogenous antioxidants can somewhat regulate the generation of free radicals, which can accelerate ageing and cause the start of many neurological illnesses (Wannang *et al*., 2008) Alcoholic extricate of *S. nigrum* demonstrated notable antioxidant action in a variety of tests, including the estimate of the net phenolic components in the plant extricate and the measurement from which the 5-lipoxygenase action (Akula *et al*., 2008). The DPPH was 92 percent inhibited by *S. nigrum* extracts in methanol, whereas the aqueous extracts shown significantly less potent radical scavenger capabilities. There was a quantifiable relationship between antioxidant activity and polyphenol concentration, indicating that the phenolics in the plant add to its capacity to scavenge free radicals. Isolated *S. nigrum* glycoproteins both have antioxidant properties in addition to methanolic extracts. Using tests like the DPPH radical assay, 2-deoxyribose degradation screening test, and peroxides scavenging assay on MCF-7 cell lines, activities are clearly specific. According to (Lee *et al*., 2003) *S. nigrum* glycoproteins efficiently and dose-dependently controlled hydroxyl radicals. However, the exact method by which the reviving cytokines interleukin [IL]-2, IL-4, IL-12, IFN, and tumor necrosis factor-alpha [TNF] serve as scavengers is yet unknown (Lee *et al*., 2003).

Anti-inflammatory activity/inflammatory conditions

Leukocytes and other complex mediator molecules, including proteinoids, erythropoietin, enkephalins, inflammatory mediators, platelet - derived growth factor, and IL-1, are released by tissues and migratory cells during an inflammation condition (Ravi *et al.,* 2009). Numerous medications and extracts made from grapes, lavender, eucalyptus, mint, turmeric, and many other plants have been utilized to reduce inflammation (Vane *et al*., 1987; Darshan *et al.,* 2004) identified the different extracts of the *S. nigrum*, identified the components that were causing the anti-inflammatory effect. The fat regulators that are concentrated more heavily during inflammatory process are leukotrienes like LTC4. Currently, anti-leukotrienes are employed to cure a wide range of inflammatory conditions, which include bronchitis and eczema dermatitis.One component of *S. nigrum,* (E)-ethyl caffeate, exhibits maximal leukotriene inhibition, which could make it an anti-inflammatory medicinal substance.

Side effects and toxicity

The majority of *Solanaceae* species are hazardous for humans and animals. The majority of the older literature claims on the plants' toxic effects. For instance, tropane alkaloids are present in deadly nightshade. When people consume toxins in significant doses, they have anticholinergic effects (Das *et al*., 2007). Though *S. nigrum* is considered to be an excellent source of nutrients, solanine, a glycoalkaloid that causes differing

levels of toxicity in a dose-dependent manner, is mainly responsible for its toxic effects (Glossman *et al*., 2007) Solanine poisoning in humans can cause a variety of symptoms, such as dizziness, headaches, nausea, vomiting, diarrhea, lack of voice, temperature, perspiration, arrhythmias, dilated pupils, blindness, mental disorientation, convulsions, and fatalities (Watt *et al*., 1962). Weather, soil quality, seasonality, and plant maturity all affect how much poisonous chemical a plant *(Watt et al*., 1962) has young green berries are typically thought to be more harmful than ripe berries. (Cooper, 1984) Given that the plant is said to be eaten upon cooking, which is likely that boiling the plant destroys the harmful components. It has long been believed that eating belongs veggies like tomato, potato, and eggplant might make arthritis patients feel worse since they aggravate their joint pain. According to some reports, the solanine found in these veggies' green sections is presumably what causes joint discomfort. Furthermore, there is a paucity of empirical evidence linking intake of *S. nigrum* to joint damage.

Anti-fungal effect

The inquiry into the anti-fungal activities of *S. nigrum* L. yielded an unexpected result: an effective farming bacterial fungus known as endophyte generates Sulphur dioxide at an exceedingly high yield. Further study might concentrate on medium manipulation, OSMAC (One Strain Many Compounds), or genetic modifiers to promote the growth of the fungus *solamargine* (El-Hawary *et al*., 2016).

Anti-larvicidal effect

It was investigated the biocontrol capability of *S. nigrum* L. ripe leaf in an ethyl acetate solution (Solanaceae). Given that the death rate (Y) was positively related to the medication ratios (X) and had a Pearson correlation coefficient close to one, the data indicated that there is dose-dependent mortality (Rawani *et al.,* 2014).

Anti-Stress effect

It was identified the active component and crude extract of *S. nigrum* leaves as possible preventive or therapeutic antioxidants. The findings show that the brain's elevated fat storage leaves it vulnerable to prooxidant damage caused by stress. As a dietary supplement, *S. nigrum* tincture of leaves or its isolated constituents can help eliminate free radicals formed in the mind as a byproduct of neurological stress or any neurological condition (Zaidi *et al*., 2014).

Cardio-protective activity

Ruby *et al*., (2012) used a global in situ ischemia perfusion injury paradigm to investigate the cardioprotective benefits of an ethyl acetate component of the *S. nigrum* berry species. Dosages of 2.5 and 5.0 mg/kg were used in this research for 6 days per week for 1 month. The fruit tincture of *S. nigrum* was shown to have cardioprotective properties (Bhatia *et al*., 2011).

Table 1. Traditional uses of *S. nigrum* for medical purposes.

Parts of *S. nigrum*	Medicinal Usage	References
Leaf	To treat ringworm, ulcers of the gastrointestinal tract, and gonorrhea; as an HPV medication; and as a liver and swallowing stimulant.	(Moshi *et al*., 2009)
Fruit	To prevent children from wetting their beds; to cure retinal detachment, ocular pneumonia, and dementia	(Moshi *et al*., 2009)
Roots	Improves female fecundity; heals coughs and other ailments of the respiratory tract	(Sikdar and Dutta, 2008)
Whole plant	As a treatment for cutaneous pustules, rashes, and blisters; snake venom (venomous snakes); and carcinogenic problems	(Javed *et al*., 2019; Javed and Kabeer 2018)

Anti-microbial activity

Ruby *et al*., (2012) illustrated the testing was performed to identify the chemicals generating these effects and to ascertain the anti-bacterial action of methyl ester and the aqueous extracts of *S. nigrum* leaves. The conclusion allows for the possible conclusion that antibacterial chemicals in leaves might be separated using acetone (Kavishankar *et al*., 2011).

Anti-HCV activity

S. nigrum (SN) seed extracts in methanol and chloroform

showed 37 % and more than HCV is respectively 50 % suppressed at nontoxic amounts. Interfering with hepatic cells with a DNA copy of the plasmid expressing HCV NS3 protease further explored the antiviral efficacy of *S. nigrum* seeds tincture when compared to HCV NS3 protease. The results revealed that GAPDH remained steady whereas aqueous Solanum extracts reduced HCV NS3 protease synthesis or activity in a dosages manner. These results suggest that SN content may include antiviral chemicals that are considerably more effective towards HCV, and that SN extract combined using interferon will be a preferable choice for treating chronic HCV (Javed *et al.,* 2011).

Antimycotic activity

Petroleum ether and 98 % methanolic young leaf extracts of *S. nigrum* were used to test *Psudomonas aeruginosa*, *Escherichia coli, Bacillus subtilis, Staphylococcus aureus, Candida albicans,* Epidermophyton, *Colletotrichum tonsurans, Microsporum gymseum*, and *Trichophyton mentagrophytes*. The commonly utilized methanolic extract surpassed the low polarizing petroleum ether extract on the project. The highest bactericidal levels, lowest fungal-killing concentration, and lowest concentration of inhibitory substances were found for each test strain (Prakash *et al*., 2011).

Allergic a**ctivity**

The study claims that ethanolic extracts of *S. nigrum* have been examined for their analgesic abilities. The heated plate of Eddy's method and induce wriggling acetic acid were used to test the extract's analgesic potency for both peripheral and central therapeutic actions. Different analgesic activities of the dehydrated fruit of *S. nigrum's* ethanolic extract have been investigated (Nirmal *et al*., 2012).

Anti-convulsant activity

The CN subsystem inhibitory pathway of Sn was discovered by examining the effect of Sn infusions by intravenous route on various Neuropharmacological limits. The engorged amphibian's rectus abdominis contracts isotonically. Inotropic and unfavorable chronotropic activity was seen in the isolated frog's heart. In cage-bound guinea pigs, isotopic ileal evacuation occurs. The rodent's limited jejunum undergoes isotonic constriction decrease in accordance with the rabbit's blood vascular pulse. Secretion's impact on the rodent's sublingual organ (Chauhan *et al.*, 2012).

CONCLUSION

We draw the conclusion that *S. nigrum,* a conventional treatment for ulcer, hepatotoxicity, and cancer, uses numerous antigenic implications in cancer and other diseases from the extensive literature review and experimental data analysis. The plant helps to avoid liver toxicity and cytotoxicity, which enhances the activities of the liver and kidney. It is also quite helpful for the functioning of CNS as well as for issues with the abdomen and general body discomfort. Given the plant's many beneficial properties, it may be endorsed as a secure, crucial medical herb for all of humanity.

REFERENCES

Akhtar M.S. and M. Munir. 1989. Evaluation of the gastric antiulcerogenic effects of *S. nigrum*, *Brassica oleracea* and *Ocimum basilicum* in rats. Journal of ethnopharmacology, 27(1-2): 163-176.

Akula U.S. and B. Odhav. 2008. In vitro 5-Lipoxygenase inhibition of polyphenolic antioxidants from undomesticated plants of South Africa. Journal of Medicinal Plants Research, 2(9): 207-212.

Al-Qirim T., S.M. Zaidi, M. Shahwan, G. Shattat and N. Banu. 2008. Effect of S. nigrum on immobilization stress induced antioxidant defense changes in rat. Research Journal of Biological Sciences, 3(12): 1426-1429.

An, L., Tang, J. T. Liu, X. M. and Gao, N. N. 2006. Review about mechanisms of anti-cancer of *S. nigrum*. Zhongguo Zhong yao za zhi= Zhongguo zhongyao zazhi= China journal of Chinese Materia medica, 31(15): 1225-6.

Atanu, F.O., U.G. Ebiloma and E.I. Ajayi. 2011. A review of the pharmacological aspects of *S. nigrum* Linn. Biotechnology and Molecular Biology Reviews, 6(1): 1-7.

Bhatia, N., P.P. Maiti, A. Kumar, A. Tuli, T. Ara and M.U. Khan. 2011. Evaluation of cardio protective Activity of Methanolic Extract of *S. nigrum* Linn. Rats. International Journal of Drug Development and Research, 3(3): 139-147.

Bin Nyeem, M. A., U.R. Rashid and A.M. Nowrose. 2017. *S. nigrum* (Maku): A review of pharmacological activities and clinical effects. International Journal of Applied Research, 3(1): 12-17.

Çaksen, H., D. Odabaş, S. Akbayram, Y. Cesur, S. Arslan, A. Üner and A.F. Öner. 2003. Deadly nightshade (*Atropa belladonna*) intoxication: an analysis of 49 children. Human and Experimental

Toxicology, 22(12): 665-668.

Chauhan, R., K.M. Ruby, A. Shori and J. Dwivedi. 2012. *S. nigrum* with dynamic therapeutic role: A review. International Journal of Pharmaceutical Sciences Review and Research, 15(1): 65-71.

Chen, R., L. Feng, H.D. Li, H. Zhang and F. Yang. 2009. Two novel oligosaccharides from *S. nigrum*. Carbohydrate Research, 344(13): 1775-1777.

Chou, F., H. Lin, H. Tseng, C. Wang, J. Lin and C. Loa. 2008. Hepatoprotective effects of *S. nigrum* Linn extract against CCl4- induced oxidative damage in rats. Chemical-Biological Interactions. 171: 283– 293.

Cooper, R.G. 1984. How new product strategies impact on performance. 1(1): 5-18.

Darshan, S., and R. Doreswamy. 2004. Patented antiinflammatory plant drug development from traditional medicine. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 18(5): 343-357.

Das, J.K.L., S.R. Prasad and S.K. Mitra. 2007. Evaluation of Liv. 52 DS tablet as a hepatoprotective agent in prophylaxis with statin therapy. Medical Update, 15(7): 31-6.

Dhellot, J.R., E. Matouba, M.G. Maloumbi, J.M. Nzikou, M.G. Dzondo, M. Linder and S. Desobry. 2006. Extraction and nutritional properties of S. nigrum L seed oil. African Journal of Biotechnology, 5(10).

Dilip, K.J., K. Saroja and A.R.V. Murthy. 2012. Pharmacogenetic study of Kamakahi (*S. nigrum* Linn). Journal of Pharmaceutical and Scientific Innovation, 1(4): 42-48.

El-Hawary, S., R. Mohammed, S. AbouZid, W. Bakeer, R. Ebel, A, Sayed and M.E. Rateb. 2016. Solamargine production by a fungal endophyte of *S. nigrum*. Journal of Applied Microbiology 120(4): 900-911.

Glossman, M.D. 2007. CHIH-DFT determination of the molecular structure and infrared and ultraviolet spectra of γ-solanine. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 66(1): 208-211.

Heo, K.S., and K.T. Lim. 2004. Antioxidative effects of glycoprotein isolated from *S. nigrum* L. Journal of Medicinal food 7(3): 349-357.

Heo, K.S., S.J. Lee, J.H. Ko, K. Lim and K.T. Lim. 2004. Glycoprotein isolated from S. nigrum L. inhibits the DNA-binding activities of NF-κB and AP-1 and increases the production of nitric oxide in TPA-stimulated MCF-7 cells. Toxicology in vitro, 18(6): 755-763.

Ikeda, T., H. Tsumagari and T. Nohara. 2000. Steroidal oligoglycosides from *S. nigrum*. Chemical and Pharmaceutical Bulletin, 48(7): 1062-1064.

Jainu, M., and C.S. Devi. 2004. Antioxidant effect of methanolic extract of S. nigrum berries on aspirin induced gastric mucosal injury. Indian Journal of Clinical Biochemistry, 19: 57-61.

Jainu, M. and C.S. Devi. 2006. Antiulcerogenic and ulcer healing effects of *S. nigrum* (L.) on experimental ulcer models: possible mechanism for the inhibition of acid formation. Journal of Ethnopharmacology, 104(1-2): 156-163.

Jami, S.K., T.S. Anuradha, L. Guruprasad and P.B. Kirti. 2007. Molecular, biochemical and structural characterization of osmotin-like protein from black nightshade (*S. nigrum*). Journal of Plant Physiology, 164(3): 238-252.

Javed, A., M. Usman, S.M. Haider, B. Zafar and K. Iftikhar. 2019. Potential of indigenous plants for skin healing and care. American Scientific Research Journal for Engineering, Technology, and Sciences, 51(1): 192-211.

Ji, Y.B., S.Y. Gao, C.F. Ji and X. Zou. 2008. Induction of apoptosis in HepG2 cells by solanine and Bcl-2 protein. Journal of Ethnopharmacology, 115(2): 194-202.

Joo, H.Y., K. Lim and K.T. Lim. 2009. Phyto glycoprotein (150 kDa) isolated from *S. nigrum* Lin has a preventive effect dextran sodium sulfate-induced colitis in A/J mouse. Journal of Applied Toxicology, 29(3): 207-213.

Kala, C.P. 2005. Ethnomedicinal botany of the Apatani in the Eastern Himalayan region of on India. Journal of Ethnobiology, Ethnomed., 1,11.

Kumar, J., A. Kaur and P. Narang. 2020. Phytochemical screening and metal binding studies on floral extract of *S. nigrum*. Materials Today: Proceedings, 26, 3332-3336.

Kumar, V.P., S. Shashidhara, M.M. Kumar and B.Y. Sridhara 2001. Cytoprotective role of S. nigrum against gentamicin-induced kidney cell (Vero cells) damage in vitro. Fitoterapia, 72(5): 481-486.

Lee, K.R., N. Kozukue, J.S. Han, J.H. Park, E.Y. Chang, E.J. Baek and M. Friedman. 2004. Glycoalkaloids and metabolites inhibit the growth of human colon

(HT29) and liver (HepG2) cancer cells. Journal of Agricultural and Food Chemistry, 52(10): 2832-2839.

Lee, S.J. and K.T. Lim. 2003. Antioxidative effects of glycoprotein isolated from S. nigrum Lin on oxygen radicals and its cytotoxic effects on the MCF-7 cell. Journal of Food Science, 68(2): 466-470.

Lee, S.J. and K.T. Lim. 2006. 150 kDa glycoprotein isolated from S. nigrum Lin stimulates caspase-3 activation and reduces inducible nitric oxide production in HCT-116 cells. Toxicology in vitro, 20(7): 1088-1097.

Li, J., Q. Li, T. Feng and K. Li. 2008. Aqueous extract of S. nigrum inhibit growth of cervical carcinoma (U14) via modulating immune response of tumor bearing mice and inducing apoptosis of tumor cells. Fitoterapia, 79(7-8): 548-556.

Lim, K., H. Heo and S. Lee. 2004. Cytotoxic effect of glycoprotein isolated from S. nigrum L. through the inhibition of hydroxyl radical induced DNA-binding activities of NF-kappa B in HT-29 cells. Environmental Toxicology and Pharmacology. 17: 45–54.

Mandal, S., P. Vishvakarma, M. Verma, M.S. Alam, A. Agrawal and A. Mishra. 2023. S. nigrum Linn: An Analysis of The Medicinal Properties of The Plant. Journal of Pharmaceutical Negative Results, 1595-1600.

Moshi, M.J., D.F. Otieno, P.K. Mbabazi and A. Weisheit. 2009. The ethnomedicine of the Haya people of Bugabo ward, Kagera Region, northwestern Tanzania. Journal of Ethnobiology and Ethnomedicine, 5, 24.

Mumberg, D., P.A. Monach, S. Wanderling, M. Philip, A.Y. Toledano, R.D. Schreiber and H. Schreiber. 1999. CD4+ T cells eliminate MHC class II-negative cancer cells in vivo by indirect effects of IFN-γ. Proceedings of the National Academy of Sciences, 96(15): 8633-8638.

Muthu, C., M. Ayyanar, N. Raja and S. Ignacimuthu. 2006. Medicinal plants used by traditional healers in Kancheepuram district of Tamil Nadu, Indian Journal of Ethnobiology and Ethnomedicine, 2, 43.

Muto, M., V. Mulabagal, H.C. Huang, H. Takahashi, H.S. Tsay and J.W. Huang. 2006. Toxicity of black nightshade (*S. nigrum*) extracts on *Alternaria brassicicola*, causal agent of black leaf spot of Chinese cabbage (*Brassica pekinensis*). Journal of Phytopathology, 154(1): 45-50.

Nderitu, K.W., E. Mecha and A. Nyachieo. 2023. *S. nigrum* show anti-obesity effects on high-fat diet-fed Sprague Dawley rats in a randomized study. Scientific African, 20, e01713.

Nirmal, S.A., A.P. Patel, S.B. Bhawar and S.R. Pattan. 2012. Antihistaminic and antiallergic actions of extracts of S. nigrum berries: possible role in the treatment of asthma. Journal of Ethnopharmacology, 142(1): 91-97.

Oh, P.S. and K.T. Lim. 2007. HeLa cells treated with phytoglycoprotein (150 kDa) were killed by activation of caspase 3 via inhibitory activities of NF-κB and AP-1. Journal of Biomedical Science, 14, 223-232.

Pandey, A., A.L. Dwivedi, I.P. Tripathi. 2021. Review Article on Pharmaceutical, Pharmacological Activities and Therapeutic Potential of "*S. nigrum*". International Journal of Research in Engineering and Science, 9(121): 1-7.

Parveen, U.B., S. Roy and A. Kumar. 2007. Traditional uses of medicinal plants among the rural communities of Churu district in Thar Desert, Indian Journal of Ethnopharmacology, 113, 387-399.

Perez, G.R.M., L.J.A. Perez, D.L.M. Garcia and M.H. Sossa. 1998. Neuropharmacological activity of *S. nigrum* fruit. Journal of Ethnopharmacology, 62(1): 43-48).

Prakash, S. and A.K. Jain. 2011. Antifungal activity and preliminary phytochemical studies of leaf extract of *S. nigrum* Linn. International Journal of Pharmaceutical Sciences, 3, 352-355.

Rani, P. and N. Khullar. 2004. Antimicrobial evaluation of some medicinal plants for their anti-enteric potential against multidrug resistant *Salmonella typhi*. Phytotherapy Research, 18(8): 670-73.

Ravi, V., T.S.M. Saleem, S.S. Patel, J. Raamamurthy and K. Gauthaman. 2009. Anti-inflammatory effect of methanolic extract of *S. nigrum* Linn berries. International Journal of Applied Research in Natural Products, 2(2): 33-36.

Rawani, A., A. Ghosh, S. Laskar and G. Chandra. 2014. Glucosinolate from leaf of *S. nigrum* L. (Solanaceae) as a new mosquito larvicide. Parasitology Research, 113, 4423-4430.

Salgaller, M.L. and P.A. Lodge. 1998. Use of cellular and cytokine adjuvants in immunotherapy of cancer. Journal of Surgical Oncology, 68(2): 122-

138.

Sharma, S.C., R. Chand, O.P. Sati and A.K. Sharma. 1983. Oligofurostanosides from *S. nigrum*. Phytochemistry, 22(5): 1241-1244.

Sikdar, M. and U.J.S.O.E.M. Dutta. 2008. Traditional phytotherapy among the Nath people of Assam. 2(1): 39-45.

Singh, S.P., K. Raghavendra, R.K. Singh and S.K. Subbarao. 2001. Studies on larvicidal properties of leaf extract of *S. nigrum* Linn. (Family Solanaceae). Current Science, 81(12): 1529-1530.

Son, Y.O., J. Kim, J.C. Lim, Y. Chung, G.H. Chung and J.C. Lee. 2003. Ripe fruits of *S. nigrum* L. inhibit cell growth and induces apoptosis in MCF-7 cells. Food and Chemical Toxicology 41(10): 1421-1428.

Sultana, S., S. Perwaiz, M. Iqbal and M. Athar. 1995. Crude extracts of hepatoprotective plants, *S. nigrum* and *Cichorium intybus* inhibit free radical-mediated DNA damage. Journal of Ethnopharmacology, 45(3): 189-192.

Tournier, C., P. Hess, D.D. Yang, J. Xu, T.K. Turner, A. Nimnual and R.J. Davis. 2000. Requirement of JNK for stress-induced activation of the cytochrome c-mediated death pathway. Science, 288(5467): 870-874.

Vane, J.O.H.N. and R. Botting. 1987. Inflammation and the mechanism of action of anti-inflammatory drugs. The FASEB journal, 1(2): 89-96.

Varshney, I.P. and S.C. Sharma. 1965. Saponins and sapogenins-XXIX: The sapogenin of *S. nigrum* L. berries. Phytochemistry, 4(6): 967-968.

Wannang, N.N., J.A. Anuka, H.O. Kwanashie, S. Gyang and A. Auta. 2008. Anti-seizure activity of the aqueous leaf extract of *S. nigrum* Linn (Solanaceae) in experimental animals. African Health Sciences, 8(2).

Watt, J.M. and M.G. Breyer-Brandwijk. 1962. The Medicinal and Poisonous Plants of Southern and Eastern Africa being an Account of their Medicinal and other Uses, Chemical Composition, Pharmacological Effects and Toxicology in Man and Animal. The Medicinal and Poisonous Plants of Southern and Eastern Africa being an Account of their Medicinal and other Uses, Chemical Composition, Pharmacological Effects and Toxicology in Man and Animal., (Edn 2).

Zaidi, S.K., M.N. Hoda, S. Tabrez, S.A. Ansari, M.A. Jafri, M.S. Khan and N. Banu. 2014. Protective effect of *S. nigrum* leaves extract on immobilization stress induced changes in rat's brain. Evidence-Based Complementary and Alternative Medicine, 2014.

Zhou, X., X. He, G. Wang, H. Gao, G. Zhou, W. Ye and X. Yao. 2006. Steroidal saponins from *S. nigrum*. Journal of Natural Product 69(8): 1158-1163.