

## Ethnobotanical Notes and Phytopharmacologiques on *Solanum nigrum* Linn. (Family: *Solanaceae*)

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### Abstract

*Solanum nigrum* Linn. (Family: *Solanaceae*) is commonly known as tit begun, *phuti begun*, *gurki*, *gurkamai* and *kakmachi*, black nightshade, duscle, Garden Nightshade, hound's berry, petty Morel, wonder Berry, small-fruited black nightshade. It is a species of the *Solanum* genus, native to Eurasia and introduced in the Americas, Australia, Asia and South Africa. Parts of this plant can be highly toxic to livestock and humans, and it is considered a weed. Nonetheless, ripe berries and cooked leaves are used as food in some locales; and plant parts are used as a traditional medicine. This paper reviews the literature on the morphology, distribution, ecology, habitat requirements, physiology and impacts, biological and pharmacological activity.

**Keywords:** *Solanum nigrum* Linn; Taxonomy; Physiology; Biology

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### Introduction

The genus *Solanum* is the biggest and the most complex of the family *Solanaceae*, it is composed of more than 1500 species, many of which are also economically important throughout their cosmopolitan distribution. This family includes fruits and vegetables such like potato (*Solanum tuberosum* L.), tomato, peppers and ornamental plants such as petunia and other medical plants like *Atropa belladonna* L. (deadly nightshade), *Datura stramonium* L. (Jimson weed), and *Hyoscyamus niger* L. (black henbane), eggplant (*S. melongena* L.) and naranjilla (quitoense *S. Lam.*). Too the species cultivated for their drug use include bittersweet like (*S. dulcamara* L.) and *S. viarum* Dun both used as sources of corticosteroids [1,2]. Although the species are distributed throughout the world, they often occur in warm temperate and tropical regions with centers of diversity occurring in the southern hemisphere, especially in South America. Other centers of speciation occur in Australia and Africa, with relatively few and less diverse species are found in Europe and Asia [3]. *S. nigrum* species are amongst the most common and popular leafy vegetables in the warm humid zones of Africa, and arguably the most important group of traditional leafy vegetables on the African continent after *Amaranthus* [4].

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### Taxonomy and morphology

**Taxonomy:** The taxonomic complexity of species associated with the section *Solanum* has long been accepted [5-10]. Various classical, experimental and numerical studies have demonstrated that the complexity is attributable to a number of causes [11-13]. Among these causes there are phenotypic plasticity [14,15], genetic variation, Polyploidy, natural hybridization, discordant variation [16]. *S. nigrum* (*solanaceae*) is one of 1500 species within the genus *Solanum*. Different from *S. nigrum*; *S. americanum* Miller; *S. chenopodioides* Lam.; *S. physalifolium* Rusby var. *nitidibaccatum* (Bitt.); *S. retroflexum* Dunal in; *S. sarrachoides* Sendtn; *S. scabrum* Miller [17]. Synonyms of *S. nigrum* (black nightshade, European Black Nightshade or locally

just "black nightshade", Duscle, Garden Nightshade, Hound's Berry, Petty Morel, Wonder Berry, Small-fruited black nightshade or popolo). The name of the genus is thought to derive from the solamen latin, and refer to the appeasement or sedative effects associated with many species of *Solanum*.

**Taxonomic position:** Kingdom: *plantae*, Order: *solanales*, Family: *Solanaceae*, Genus species: *solanum nigrum*.

### Morphology

*S. nigrum* L commonly as Black nightshade is a dicot weed in the *Solanaceae* family. It is an annual herbaceous plant of 30-100 cm high, pubescent with simple hairs. Stems are often angular, pubescent-pubescent. The opposite leaves, with whole limb, oval and diamond shape are slightly cogged, the bases are cuneate, 4-10 and 3-7 cm wide, pubescent, entire or coarsely dentate, the apex is obtuse. Inflorescences are extra-axillary umbels, the calyx cup-shaped, the corolla is white, 8-10 mm long, the lobes ovate-oblong, pubescent abaxially, ciliate spreading. Filaments are 1-1.5 mm long, anthers oblong, 2.5-3.5 mm. Fruiting 2 pedicels are strongly deflexed. The fruiting calyx is applied to the berry. The flowers are sometimes white veined with purple, with a flat corolla; they are grouped by 3 or 5 along the stem. The fruits are dull black, globose, 8-10 mm in diameter. The fruits are spherical berry 8-10 mm in diameter, green and greenish yellow to black laying maturity (**Figure 1**). The fruits are toxic, so they will are not richer toxin when they are degraded to maturity. Their alkaloid content varies depending on the location of the plant where it grows and depending on the season [18].

### Distribution and habitat

The black nightshade is widely distributed in various habitats throughout the world, from tropical to temperate regions and from sea level to altitudes exceeding 3500 m [19]. It is a rather common species in wet woods, near river, wasteland, old field, ditches roadside and cultivated land. Their wide tolerance of habitat types, their ability to flower while still young and their prolific seed production all contribute to the success of these species as widespread weeds [15]. They are generally found in disturbed habitats, such as roadsides, often on arable land especially the edges of cultivated fields and plantations, in hedgerows, on railway cuttings, quaysides and rubbish tips, in areas around buildings and houses, under trees, on forest and grassland margins, as garden weeds, on shingle beaches, riverbanks and in gullies. The species mainly colonize moist environments, only occurring in areas of low rainfall when the land is subject to irrigation. This plant grows well in fertile soils, especially those rich in nitrogen or phosphorus [20].

### Reproduction

Reproduction is principally by seed, but the use of shoot cuttings as propagules, especially during the rainy season, has also been reported, though plants propagated in this way yield less than those propagated by seed [21]. Plantlets have also been regenerated from '*S. nigrum*' mesophyll chloroplasts [22]. The species belonging to the *Solanum* genus are predominantly self-pollinating or autogamous though natural out- and cross-

breeding can and does occur [23]. Salisbury reported that the average production of each plant of *S. nigrum* is about 240 berries in Britain, the old plants can produce more than 3,600 seeds where each berry contains about 40 seeds. With over 90% of these seeds germinate during the following season [23]. Therefore, the potential for harm of this species as a weed is clearly seen. Similar data are recorded by other authors *solanum nigrum* can be achieved a 178000 seeds/plant [20].

### Ecology

**Water stress:** *S. nigrum* species are intolerant to water stress. An annual rainfall of 500-1200 mm is needed for optimum growth [21]. They grow on a wide range of soil types, but thrive best on fertile soils, especially those high in nitrogen and phosphorous [24].

**Contaminated soils:** *S. nigrum* L is considered to be a potential plant for restoring Cd contaminated soils. In a post-culture experiment, it would accumulate Cd up to 103.8 and 124.6 mg/kg DW in stem and leaves respectively, without phototoxic symptoms and reduction growth [25]. However *S. nigrum* has a potential to purify Cd contaminated soils [26]. Through to the high tolerance of *S. nigrum* to cadmium, the diversity of endophytic bacteria associated with Cd hyperaccumulator plant *S. nigrum* L. grown in mine tailings has been determined [27] however, among these endophytic bacterial we find: Proteobacteria (61.93%; 19 OTUs), other clones belonged to Bacteroidetes (12.18%; 5 OTUs), Firmicutes (2.03%; 2 OTUs), Actinobacteria (18.78%; 10 OTUs) and uncultured bacteria (5.08%; 4 OTUs). The dominant genera were *Sphingomonas* and *Pseudomonas*, which accounted for 24.37% and 12.18% of total clones respectively. Also he shows that *Pseudomonas* sp. LK9 would improve the nutrition supplies of N, Fe and P enhance soil heavy metal availability and affect host mediate of MWOAs secretion in soils, resulting in a significant increase of shoot biomass and metal uptake of *S. nigrum* growing in multi-metal -contaminated soils.

**Pests and diseases:** Black aphids can cause a reduction in the harvest, also they can infest the inside of the leaves causing leaf curling and infestation sum of heights of plants prevents their development. Flea beetles also attack plants resulting significant damage, in addition *Zonocerus variegatus* induce big damage to fruit wall [28]. In West Africa during the winter viral epidemic "compensation vein yellow" *S. nigrum* attack by viruses transmitted by whiteflies (*Bemisia tabaci* (Genn.)) inducing leaf yellowing. Fungal diseases do not seem a big problem for this species. For this, they can be infected by *Cladosporium oxysporum*



**Figure 1** Morphological description of *Solanum nigrum* L. A: Stem; B: Flowers; C: Fruits.

Berk. M. A. and Curtis. This pathogen can be controlled by regular spraying with a suitable fungicide [28].

### Principal uses

**The traditional uses:** *S. nigrum* has been extensively used traditionally to treat various ailments such as pain, inflammation and fever. This plant is also used in the Oriental systems of medicine for various purposes - as an antitumorigenic, antioxidant [29], diuretic and antipyretic agent, anti-inflammatory [30], hepatoprotective [31], so antibacterial and antiulcer. Various compounds have been identified which are responsible for diverse activities. The leaves contain rich amount of calcium, iron, phosphorus, carbohydrates, protein, fat, crude fiber, and minerals. This herbal plant is used as medicine for asthma, vomiting of blood, reducing blood glucose level and bilious matter phlegmatic rheumatism and ulcer [32]. Also he has been used for treating liver diseases [33]. The juice of the berries is used as antidiarrheal, ophthalmic, hydrophobicity, and for dropsy, heart disease, diuretic. Seeds are useful in vertigo. The roots are helpful in ophthalmopathy, rhinopathy and hepatitis. It was reported earlier that the aerial parts of *S. nigrum* is believed to provide its anti-ulcer action of acid and peptic suppression of aspirin induced in rats ulcerogenesis [34].

### Toxicity and deleterious properties

**Toxicity:** In ancient literature, *S. nigrum* species are considered noxious and poisonous to animals and humans. Indeed, the toxicity is widely attributed by the alkaloid solanine. The effects of solanine poisoning in the human beings are reported as nausea, vomiting, diarrhea, abdominal cramps, headache, dizziness, speech loss, fever, sweating and tachycardia, reduced heart rate, pupil dilation, blindness, mental confusion, convulsions, coma and death [35,36]. These effects usually appear about eight hours after ingestion. In animals, ingestion can cause rapid heartbeat and breathing, thus dark color diarrhea followed by constipation, lack of rumination, drowsiness and dry mouth in cattle, low body temperature, swelling, in coordination, tremors and staggering movements [37]. However, the degree of toxicity depends of the quantity of solanine. *S. nigrum* tolerates a large concentration of nitrate nitrogen ( $\text{NO}_3\text{-N}$ ) or it may cause animals toxicity by  $\text{NO}_3\text{-N}$ . In addition, acute toxicity by nitrate can lead to death and the chronic toxicity results in a decrease in milk production, abortion, muscle tremors, staggering gait, rapid heartbeat, frequent urination, labored breathing, followed by collapse and coma, with or without convulsions. However, the degree of nitrates toxicity can cause adverse effects on human health and animal production is uncertain, while actual effects observed after ingestion of plants nightshade could be due either to the solanine or  $\text{NO}_3\text{-N}$  or both [37]. Nevertheless, a chemical investigation of various members of the *S. nigrum* reported the presence of potentially toxic alkaloids in unripe fruit, with ripe berries and vegetative parts nailing these compounds. Thus, these plants are probably toxic to livestock that could consume the entire plant. However, these plants are used as fodder for animals without any adverse effect in some areas [38]. So the evolution of toxic levels of these alkaloids depends on their

growth as a result of climatic and regional conditions, and even the age of the plants concerned [36,39]. The boiling bodies *S. nigrum* destroyed all the inherent toxicity of these species, or most ethnobotanical reports of their use as vegetables refer to the kitchen or cooking requires the rejection of liquid boiling. Other similar contributions show the toxicity of immature berries. However, drying does not destroy the toxic alkaloid solanine kind (glycosidal of alkaloids that are responsible for the bitter taste often associated with this species) [40].

**Deleterious properties:** *S. nigrum* is included among the worst weeds in the world, Harmful to agriculture and horticulture in most regions of the world (grains, garlic, barley, potato, etc.) [20,39]. *S. nigrum* is in competition with cultures for humidity, light and nutrients; also it can contaminate the culture through coloring liberated by walls berries which greatly reduces the quality and economic viability of the culture producers [41,42]. Black nightshade is associated with a wide spectrum of nematodes and microorganisms potentially destructive [43].

Among these pathogens we find Nematodes like *Rotylenchus similis*, *R. similis*; *Aphelenchoides ritzembozi*; *Heterodera marioni*, *Meloidogyne spp.*; *Pratylenchus neglectus*; *Meloidogyne hapla*; *Ditylenchus destructor*; *Rotylenchus reniformis*; *Ditylenchus phyllobis*, *Nothangirina phyllobia*; *Meloidogyne incognita*; *Tylenchorhynchus claytoni*; *Heterodera schachtii* [39]. Pathogenic bacteria: *Xanthomonas vesicatoria*; *Pseudomonas solanacearum*; *Pseudomonas tabaci*.

Fungal pathogens: *Colletotrichum atramentarium*; *Cercospora nigrescens*, *Diporotheca rhizophila*, *Alternaria solani*; *Fytophthora infestans*, *Macrophoma de subconica*, *Erysiphe cichoracearum*, *Rhizoctonia solani*, *la rouille (Puccinia subtriata)*, *la septoriose solanina*, *brûlure sud (Sclerotium rolfsii)*, *la verticilliose (Verticillium albo-atrum)*, *rhizoctone violet (Rhizoctonia crocorum)* et *le charbon blanc (Entyloma de australe)*.

### Chemical composition of *S. nigrum*

*S. nigrum* is so rich on secondary metabolites such as the total alkaloids, steroid alkaloids, and steroid saponins glycoprotein, which showed anti-tumor activity. In addition flavonoids, tannins, saponins, glycosides, proteins, carbohydrates, coumarins and phytosterol [44]. Immature berries of *S. nigrum* contents had large solasodine but decreases fruit ripening [45]. Recently studies show 4 new steroidal glycosides alkaloids solamargine, solasonine,  $\alpha$  and  $\beta$  solanigrinechez isolated by berries of *S. nigrum*. Chemical analysis of the methanol extract of root and stem shows a steroidal genin saturated identified as tigogenin (glycoside and two spirosestanol furostanol glycosides) by mixed melting point and IR spectroscopy [46]. Among the new compounds recently experienced solanigrins-CH and degalactotigonin two steroidal saponins (called Nigrumnins I and II), two new disaccharides (BD-thevetopyranosyl ethyl-(1-4)-BD-oleandropyranoside and BD-thevetopyranosyl ethyl-(1-4)-a-Doleandropyranoside) identified by spectroscopic methods. The seeds of *S. nigrum* have a high fat content and are considered an important source of linoleic acid [47] and contain solanine, protein, oleic acid, palmitic acid and stearic acid and sitosterol [48]. The leaves are a rich source

of riboflavin. They also contain nicotinic acid and vitamin C, beta-carotene, citric acid, protein, lipid, steroid alkaloids glycol, solasonine and solamargine acid. Fruits contain saponins and alkaloids steroidal glycol, solanine, solamargine, solasonine a-b, and solanigrine aglycone, solasodine, Genin steroidal trigogenin (Table 1). All parts and immature green contain steroidal glycosides, as glycoalkaloids. In the genus *Solanum* are important both ecologically and commercially. In the genus *Solanum* are important both ecologically and commercially. They are widely considered defensive allelochemicals of plants against pathogens and predators. In economic terms, they are used in place of steroid sapogenin diosgenin as raw material for the industrial production of corticosteroids. The main steroid alkaloids are Solanine and solasonine [49-55].

### Essential oils

The volatile compounds of essential oil from wild *S. nigrum* have determined by head-space/solid-phase micro-extraction (HS/SPME) and gas chromatography/mass spectrometry (GC/MS). Essential oils extracted shows the following composition : Dillapiole (22,22%), un cadinol (16,47%), para-cymène (10,01%), (E)-1- (2,6,6-triméthyl 1,3-cyclohexadiène-1-yl)-2-butène-1-one ou b-damascénone (9,08%), a-phellandrène (8,48%), b-pinène (5,93%), un-bisabolol acétate (4,53%), (Z,E)-4,6,8-Megastigmatriene (4,09%), Phytol (2,49%), Linalyl butanoate (2,13%), 8-méthylène-tricyclo [3.2.1.0 (2,4)] octane (2,60%) et le limonène (2,03%) [56].

### Biological and pharmacological activity

The richness of the species *S. nigrum* biologically active compounds has enabled the species of this genus in front of the pharmaceutical scene.

**Antibacterial activity:** The crude extracts of leaves, seeds and roots of *S. nigrum* showed a potent antibacterial and antifungal activity. Thus, the sensitivity of microorganisms to Depond crude extracts of the nature of the solvent and tested microorganism [57-67]. The methanol extracts of the leaves and seeds of *S. nigrum* show potent activity against all microorganisms namely; *Escherichia coli*, *Citrobacter*, *Shigella flexenari*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Yersinia aldovae*; *Cereviciae Saccharomyces*, *Aspergillus parasiticus*, *Trichophyton rubrum*, *Macrophomina*, *Fusarium solani* and *Candida albicans* [68]. Although, the ethanol extract of the root shown as well antifungal activity against *A. brassicicola* [69]. The ethanol and ethyl acetate extracts of methanol leaves, the seeds and the roots were analyzed for their antifungal activity against fungal strains such as *Penicillium notatum*, *Aspergillus Niger*, and *Trichoderma viridae Fuserium oxisporium* or diameter d inhibition was compared to the standard antibiotics. Only extracts from seeds that have antifungal activity [70].

**The anti-HCV activity:** Recent research of Javed sign that methanol and chloroform extracts of seeds contains potential antiviral agents against HCV, which extracts exhibit an inhibition rate of HCV varies from 37% to 50% respectively at nontoxic doses. The chloroform extract decreases the functioning of the HCV protease in a dose dependent manner) [71,72].

**Table 1** Chemical composition of *S. nigrum*.

Class of compound	Compound Name	References
Steroide Glycoalkaloides	Solasodine	[49]
	12β,27-dihydroxysolasodine	[50,51]
	23-O-acetyl-12β- Hydroxysolasodine	[52]
	N- Methylsolasodine	[50]
	Solasonine(-Solanigrine)	[53,54]
	α-Solamargine (-Solanigrine)	[49,54,55]
	Solanigridine	[49]
	β-Solamargine	[55]
	Solanine (α,β)	[56]
	Tomatidenol	[50]
	Solaviol	[51]
	Solanocapsine	[50]
	Solasodi-3,5-ene	[57]
Saponine	Diosgenin	[58]
	Tigogenin	[52]
	Desgalactotigonin	[59]
	Nigrumnin I	[60]
Sterols	Nigrumnin II	[60]
	Cholestrol	[61]
	Campesterol	[61]
	Stigmasterol	[61]
	β-Sitosterol	[61,72]
Flavonoides	Quercetin-3-glucosyl-(16) galactoside	[62]
	Quercetin-3-gentiobioside,	[62]
	Quercetin-3-galactoside	[62]
	Quercetin-3-glucoside	[62]
	Quercetin 3-O-(2Gal- rhamnosyl)-glucosyl(16)- galactoside	[62]
	Isoquercitrin	[62]
Carotenoides	Quercetin3-O- rhamnosyl (12)-galactoside	[62]
	β-Carotene	[63]
Vitamines	Vitamin C	[63]
Acides gras	Palmitic acid	[72]
	Palmitoleic acid	[72]
	Stearic acid	[72]
	Linoleic acid	[72]
	Squalene	[72]
	Uttronin-β-Dglucopyranosyl	[64]
	Uttronin-β-Dxylopyranosyl	[64]
	Uttroside-β-D-glucosyl	[64]
	Tricarboxylic Acid	Citric acid
Fructose		[63]
Carbohydrates	D-glucose	[63]
	L-Rhamnose	[65]

**The hepatoprotective activity:** Some research reported that the water extract of *S. nigrum* have a protective effect against liver damage were evaluated in carbon tetrachloride (CCl<sub>4</sub>)-induced chronic hepatotoxicity in rats. However this study suggest that *S. nigrum* could protect liver against the CCl<sub>4</sub> induced oxidative damage in rats and this hepatoprotective



effect might be contributed to its modulation on detoxification enzymes and its antioxidant and free radical scavenger effects. So the Oral administration of *S. nigrum* significantly reduces thioacetamide-induced hepatic fibrosis in mice, probably through the reduction of TGF-1 secretion [73]. Also, the methanol extracts of *S. nigrum* have hepato-protective effects against liver injury induced by injection of  $\text{CCl}_4$  in rats. These effects are signed by decreased serum aspartate aminotransferase (AST), alanine amino-transferase (ALT), alkaline phosphate (ALP) and a significant decrease in bilirubin in rats treated with the extract methanolic compared to untreated group [74]. The hepatoprotective activity of the ethanol extract of *S. nigrum* berries has confirmed; albeit the effect of the extracts was evaluated by the assay of serum protein, Serum bilirubin and serum enzymes like Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT) and Markers for oxidative stress like Glutathione (GSH), Superoxide Dismutase (SOD), Lipid Peroxidase (LPO) and histopathological studies of liver. In the groups where hepatic injury induced by  $\text{CCL}_4$  and extract were given simultaneously, the toxic effect of  $\text{CCL}_4$  was controlled significantly ( $<0.05$ ) by maintenance of structural integrity of hepatocyte cell membrane and normalisation of functional status of liver. Histology of liver sections from *S. nigrum*+ $\text{CCL}_4$  treated rats revealed moderate centrilobular hepatocytes degeneration, few areas of congestion with mild fatty changes. The extracts of *S. nigrum* possess significant hepatoprotective activity in comparison to standard drug Silymarin [75].

**The antioxidant activity:** The researchers have been succeeding to isolate a glycoprotein (150 KDa) from ethanolic extract of fruit of *S. nigrum*. This glycoprotein has scavenging activity against DPPH, OH, O. radical. In particular this glycoprotein has a non-specific radical scavenging activity in the DPPH assay, which was similar to that of ascorbic acid. So, in the deoxyribose assay for the OH radical, the *S. nigrum* glycoprotein highly removed OH radical deduced from deoxyribose degradation. However, they concluded that *S. nigrum* glycoprotein function as natural antioxidant [76]. Also, the antioxidant activity of *S. nigrum* has confirmed by highlighting the protective effects of lunasin against oxidative DNA damage. However, this lunasin peptide compound has been purified from *S. nigrum*, it did not scavenge generated hydroxyl radical, although the lunasin blocked the generation of hydroxyl radical by chelating  $\text{Fe}^{2+}$  ion [77].

**Cardio-protective activity:** The cardioprotective activity of the methanol extract of the fruit was evaluated with an *in vitro* total injury ischemia-reperfusion performed 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 ( $p<0.001$ ) of the cardioprotective activity against the ischemia-reperfusion. The activity took place independently of the dose. The methanol extract of berries *S. nigrum* has a cardio-protective activity [78].

**Analgesic activity:** Ethanol extracts of *S. nigrum* was evaluated for analgesic activity. The analgesic activity of the extract was evaluated for its central and peripheral pharmacological action using the hot plate Eddy and acetic acid-induced writhing respectively. The study was carried out using doses of 100, 250

and 500 mg/kg orally, or extract shows a positive result of the analgesic activity [78].

**Antidiarrheal activity:** The ethanol extract of dried fruits of *S. nigrum* was evaluated for anti-diarrheal activity. The fruit extract showed a significant increase ( $P<0.01$  and  $P<0.001$ ) anti-diarrheal activity against castor oil to induce. Diarrhea in mice in which it reduced the frequency of defecation and increase the average latency period at a dose of 250 mg/kg and 500 mg/kg body weight [78].

**The cytotoxic activity:** The ethanol extract of dry fruits of *S. nigrum* Linn. The cytotoxic activity is highlighted by the lethality test brine shrimp, the extract showed significant cytotoxicity with  $\text{LC}_{90}$  and  $\text{LC}_{50}$ =63.10  $\mu\text{g/ml}$ =160  $\mu\text{g/ml}$  [78].

**The anti-inflammatory activity:** The methanolic of whole plants of *S. nigrum* extract were investigated for anti-inflammatory activity in experimental animal models. The MeOH extract at a dose of 100 mg/kg body weight and 200 mg/kg body weight have shown a significant anti-inflammatory dose-dependent activity. The standard drugs were indomethacin (10 mg/kg) and cyproheptadine (8 mg/kg) [79]. Ethanol extracts of *S. nigrum* were evaluated for anti-inflammatory activity using Carrageenan induced rat paw edema. The study was carried out using doses of 100, 250 and 500 mg/kg orally. The anti-inflammatory activity at a dose of 500 mg/kg ( $P<0.01$ ) as compared to the standard drug diclofenac sodium (50 mg/kg) [80]. The effect of methanol extracts of *S. nigrum* fruits were studied on carrageenan induced paw edema. This extract decreased the edema induced in the hind paw with a dose (375 mg/kg body weight) showed significant anti-inflammatory [48].

**Anticancer activity:** Anticancer activity has also been demonstrated that ethanol extract from ripe fruits of *S. nigrum* inhibit the proliferation of human MCF-7 breast cancer cells and induce cell death by apoptosis [81]. The *S. nigrum* glycoprotein (a molecular weight 150 KDa) has a potent cytotoxic effect on the TH-29 cells. However, additions of *S. nigrum* glycoprotein with OH radical contribute together to the cytotoxicity of HT-29. Also the *S. nigrum* glycoprotein has a strong antioxidant activity and regulator affect to NK-B, so the latter effect, in turn, induces cells death by apoptosis. In conclusion, the *S. nigrum* glycoprotein can be considered to have pharmacological values as a preventive agent for colon cancer [76]. Also the research has shown that the aqueous extract of *S. nigrum* has been reported to demonstrate approximately 40% cell growth inhibition in HepG2 cells [82]. Recent research shows the methanol extracts of fruits were tested for their inhibitory effect on the cell line the HeLa. The percentage of viability of the cell line was performed using Trypan blue dye exclusion method. The MeOH extract where significant cytotoxicity on HeLa cell line in the range of concentration between 10 mg/ml to 0.0196 mg/ml using the SRB assay [83]. The main phytoconstituents of whole plant *S. nigrum* have been reported to act in various tumors, although the solamargine and solasonine inhibits growth and spread of various cancers, including breast, liver, lung and cyst cancers and leukaemia. Also the steroidal glycosides inhibit growth and spread of colon cancers and pheochromocytoma. The polysaccharides of this

herb have significant inhibitory effect on growth of liver cancer by two distinct anticancer activities [84].

**The anti-epileptic activity:** Aqueous extract of the leaves of *S. nigrum* was evaluated for anti-epileptic activity in chicks, mice and rats by extract administration by intraperitoneal route. At a time of 30 min pretreatment and graded doses, animals were challenged with different types of proconvulsant. The result indicates that the aqueous extract of leaves acted significantly ( $P < 0.05$ ), dose-dependent protection against electrically induced seizure in chicks and rats, pentylenetetrazol induced seizure in mice and rats and seizure picrotoxin induced in mice and rats. The anti-seizure property of the extract was potentiated by amphetamine. The anticonvulsant potential of herb *S. nigrum* has been revealed with the aqueous extracts with solasodine and diosgenin compounds could be used for treatment of Epilepsy [85].

**Hypoglycemic activity:** The ethanol extract of *S. nigrum* leaves in rats having hyperglycemia (alloxan monohydrate) induces a reduction in the level of blood glucose significantly in a dose dependent manner from 2 h to 10 h of study, while glibenclamide standard drug has shown similar effect during the experiment. Treatment with Alloxane causes permanent destruction of  $\beta$  cells and impaired renal function and sulfonylurea drugs are known to lower the level of glucose in the blood by stimulating  $\beta$  cells to release insulin [86]. However, the ethanol extract of *S. nigrum* has anti-hyperglycemia effects and may suggest additional effects on the pancreas and intra-intestinal shares [87]. The aqueous extracts of *S. nigrum* significantly reduced glucose and other lipid parameter at doses between 200 and 400 mg/kg body weight of diabetic rats for 21 treatments. These findings show the antidiabetic potential of this plant [88]. The recent research indicated that aqueous extracts of leaf and berries having an effect significant hypoglycemic effect in dose independent manner. Moreover the stem extract hasn't a profound effect [89].

**Anti-gastritis activity and anti-ulcerogenic effects:** *S. nigrum* is considered anti-gastritis and anti-ulcerogenic. This activity can be explained by the presence of antioxidant vitamins, minerals, tannins and other phytochemicals. With other studies specific active constituents can be identified and their mechanism of action can be elucidated. This plant has both anti-gastritis and antiulcer effects. With the combination of nutrients and antioxidant phytochemicals have great therapeutic importance as preventive functional food [90]. Thus the fruits of *S. nigrum* are can be considered protective gastric by their action against free radicals [91]. However, in the previous study, it was found that water extract, ethanol extract and n-butanol extract of *Solanum*

*nigrum* L. could inhibit the growth of human gastric cancer MGC-803 cells [92]. Six steroidal glycoalkaloids from *S. nigrum* has isolated and purified by acid extraction and alkaline precipitation. Experimental results showed that compounds solasonine, b1-solasonine, solamargine and solanigraside P have cytotoxicity to human gastric cancer MGC-803 cells [93]. Also, the aqueous leaf of *S. nigrum* inhibited the aspirin induced and pyloric ligated ulcer models on experimental rats. Further, this extracts also shows spasmolytic effect on ileum contraction [94]. The petroleum ether extract of *S. nigrum* berries can inhibits parameters linked to the asthma disease. Since, it contains an antiasthmatic compound "b-sitosterol", and significantly inhibited increased leukocyte and eosinophil count due to milk allergen and showed maximum protection against mast cell degranulation by clonidine [95].

### Other activity

The ethanol extract of whole plants of the *S. nigrum* exerted cytoprotection against gentamicin-induced toxicity on Vero cells. However, the protection of the cells from the effects of gentamicin (increasing in the cells permeability, a decrease in mitochondrial dehydrogenase activity) has been determined through the incubation of the Vero cells with the different concentrations of the dried 50% ethanol extract [96]. Also, the researchers have succeeded to synthesize a silver nanoparticle by using the aqueous extracts of *S. nigrum*. These nanoparticles are spherical to polyhedral in shape with size of 50-100 nm. In larvicidal bioassay with synthesized AgNPs, highest mortality are observed at 10 ppm against *An. stephensi* with LC 50 values of 1.33, 1.59, 1.56 ppm and LC 90 values of 3.97, 7.31, 4.76 ppm for dry leaves, fresh leaves and berries respectively. So the Antibacterial activity test reveals better results against fish pathogenic bacteria than human pathogenic bacteria. Moreover, the silver nanoparticle hasn't any effects and anomaly in the organism as *Toxorhynchites* larvae (mosquito predator), *Diplonychus annulatum* (predatory water-bug) and *Chironomus circumdatus* larvae (chironomid) are also exposed to respective lethal concentrations [97].

### Conclusion

*Solanum nigrum* have been used since time immemorial/ antiquity for the treatment of human ailments. Even today, the traditional systems of medicine continue to be widely practiced. Their use as such is recorded from the earliest times and various species, especially *Solanum nigrum*, are mentioned and often illustrated in all of the early Herbals, with Dioscorides being one of the first to record their medicinal properties. Since then this 'species has continued to be widely acclaimed for its medicinal effects in every country in which the taxon is found.

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