



SOLANUM NIGRUM WITH DYNAMIC THERAPEUTIC ROLE: A REVIEW

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ABSTRACT

Solanum nigrum belongs to family Solanaceae. Makoi and Blacknightshade are the common names for it. Chemical constituents commonly found in *Solanum nigrum* are glycoalkaloids, glycoproteins, polysaccharides, polyphenolic compounds such as gallic acid, catechin, protocatechuic acid, caffeic acid, epicatechin, rutin. It is known to possess various biological activities like antibacterial, antifungal, anti-inflammatory, anticancer, anti-oxidant, antipyretic and cytotoxic activity. Root, whole plant and leaves are used but fruits of black colour are not used as they possess toxicity, therefore they are not used for medicinal purposes. Reddish brown coloured fruits are used for edible purpose.

Keywords: *Solanum nigrum*, Medicinal activity, Antimicrobial activity, Anti-oxidant and Anticancer activity, Chemical constituents, Polyphenolic compound.

INTRODUCTION

Solanum nigrum is a medicinal plant belonging to the family Solanaceae.¹ Its common names are Makoi and blacknight shade.^{1,2} Two varieties of *Solanum nigrum* found one is black colour fruit and second is reddish brown colour fruit. In both varieties black colour fruit are toxic.⁴ Leaves, whole plant and roots are used for health point of view.³

Scientific classification

Kingdom: Plantae

Order: Solanales

Family: Solanales

Genus: *Solanum*

Species: *nigrum*



Whole Plant



Fruit

Morphology

Solanum nigrum is 25-100 cm tall, erect annual herb, pubescent with simple hairs. Stems are often angular, sparsely-pubescent. The fruits are dull black, globose, 8-10 mm in diameter. The leaves are ovate, the bases are cuneate, 4-10 and 3-7 cm wide, pubescent, coarsely dentate, the apex is obtuse. Inflorescences are extra-

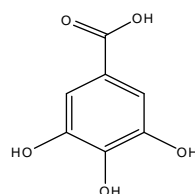
axillary umbels, the calyx cup-shaped, the corolla is white, the lobes ovate-oblong, pubescent abaxially, ciliate spreading. Filaments are 1-1.5 mm long; anthers are 2.5-3.5 mm long.⁴

Traditional Uses

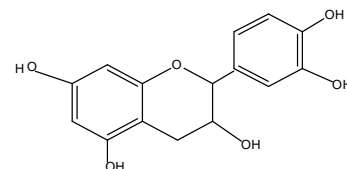
S. nigrum has been used traditionally to treat various ailments such as pain, inflammation fever^{5,6} and enteric diseases.⁷ It possess many activities like antitumorigenic, antioxidant,⁸ anti-inflammatory,⁶ hepatoprotective,⁹ diuretic,^{3,6} and antipyretic agent,^{3,6} antibacterial,⁷ mycotic infection,¹¹ cytotoxicity, anti-convulsant, anti-ulcerogenic.^{13,14} It is also used against sexually transmitted diseases.¹²

Chemical constituents

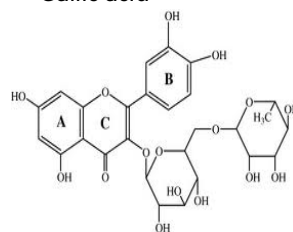
S. nigrum possesses numerous compounds that are responsible for pharmacological activities. Its active components are glycoalkaloids, glycoproteins, and polysaccharides, polyphenolic compounds such as gallic acid, catechin, protocatechuic acid (PCA), caffeic acid, epicatechin, rutin, and naringenin.¹⁵



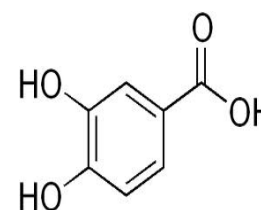
Gallic acid



(+)-catechin



Rutin



Protocatechuic acid



Ethanol extract of *Solanum nigrum* is used to determine phytochemical and pharmacological activities in experimental animal models. The ethanol extract of *S. nigrum* was used in three different doses (100, 200 and 300 mg/kg b.w) to evaluate anti-inflammatory and anticonvulsant activity by employing carrageenan paw edema and supramaximal electric shock (MES) methods. Ethanol extract of *S. nigrum* produced significant anti-inflammatory ($P < 0.01$) and anticonvulsant ($P < 0.05$) effect in dose dependent manner. The flavonoids present in the berries might be a responsible active constituent for this activity.¹⁶

The aqueous and hydro-alcoholic extracts of leaf, fruit and stem were determined for proximate analysis. Ash values determined were; for leaf 3.928, fruit 6.723, stem 11.90, whereas for crude fibre of leaf, fruit, and stem were 8.42, 15.19, 14.73 respectively. Potassium and sodium were analyzed for all the parts which revealed that the leaves have the highest content of K and Na 2.6ug/mL & 0.75ug/mL respectively.¹⁷

Mineral and phytochemical contents of leaves of *Solanum nigrum* L. Subjected to different processing methods were evaluated. Processing procedures adopted include shredding, sun-drying, oven-drying, steaming and a combination of these. Minerals examined are Na, K, Ca, Mg, Fe, P, and Zn while the phytochemicals are alkaloids, flavonoids, hydrocyanic acid, phenols, phytic acid and tannins. Oven – drying was the most effective method for retaining the studied minerals in *S. nigrum* but only for Na, Ca, Fe and Mg.¹⁸

The phytochemical screening of the crude extract show the presence of alkaloids, reducing sugars, tannis, flavonoids, phlobatannis and steriods. The extract were subjected for identification of functional groups using infrared spectrophotometer, presence of C=O, C-H, C=C and CO were identified, these bonding structures are responsible for presence of alkyl groups, methyl groups, alcohols, ethers, esters, carboxylic acid and anhydrides. Crude ethanol extract of *Solanum nigrum* was assayed for *in vitro* antimicrobial activity against gram positive and gram negative bacteria and it was also subjected for antifungal activity and the zone of inhibition was compared with control drug Penicillin and Nystatin. *Staphylococcus aureus* as the most sensitive strains exhibited maximum zone of inhibition about 25.7mm among gram positive organism tested. *Escherichia coli* exhibits 30.1mm zone than that of standard penicillin positive control. *Trichophyton mentagrophytes* exhibited maximum zone of inhibition of about 26.1mm among the tested fungal species.¹⁹

The nutritional potential of the leaves and seeds of *Solanum nigrum* L. was assessed by determining proximate and phytochemical composition. Results indicated protein content of the leaves and seed as 24.90% and 17.63% respectively. *Solanum nigrum* leaves and seeds had ash value of 10.18% and 8.05% respectively, crude fibre content 6.81% and 6.29%,

whereas carbohydrate content was 53.51 and 55.85%. Mineral analysis revealed the order Mg> K> Ca> Fe> Na> Mn> Zn in the leaves and Mg> K> Fe> Ca> Na> Mn> Zn in the seeds. Phosphorus and sulphur levels were 75.22 and 8.55 mg/100g in the leaves and 62.50 and 14.48, g/100g in the seeds. Vitamin content indicated the order vit C> vit B> Folic acid> Vit E> Vit A in both the leaves and seeds. Phytochemical analysis revealed high oxalate, phenol but low sterol content in the studied plant materials. Cyanide levels were higher in the leaves compared to the seeds.²⁰

A physicochemical study of *Solanum nigrum* L seeds was carried out and three chemical methods (Soxhlet, Bligh and Dyer, and Folch) were used to extract the oil. The dry matter content of the seeds is 94.22%. Average lipid content varies between 34.5 and 37.5%, proteins content is 17%, dry matter and crude ash content average is 7.18% and the principal mineral element is Mg (180 mg/100g). The acid value of the oil is about 2.5, saponification value varies between 157.3 and 190.1, peroxide value is low at 5.13 and iodine is 102.33. The fatty acid compositions of *S. nigrum* seeds oil shows that it has 67.9% of linoleic acid, indicating its high unsaturation. Apart from linoleic acid, other prominent fatty acids were palmitic, stearic and oleic acids. The following average profile is: 18: 2n-6 > 18: 1 n-9 > 16: 0 > 18: 0. The oil is liquid at room temperature and green in colour. Oil viscosity varies between 20 and 35 mPa.s at 25°C. Three activation energies which vary between 0.8 to 26.58 kJ.mol⁻¹ were determined using Arrhenius's equation. The melting points estimated by differential scanning calorimetry were found to be between -22.0 and -12.0°C for the Soxhlet and Folch-extracted oils. Bligh and Dyer oil have three melting points at -36.2, 15.2 and 33.7°C.²¹

PHARMACOLOGICAL ACTIVITY

Antidiabetic activity

The aqueous and hydro-alcoholic extracts of different parts of *Solanum nigrum* plant, viz leaf, fruit and stem for hypoglycemic activity in Sprague Dawley rats. Different doses of the extract 200, 400mg/kg body weight were employed to evaluate the oral glucose tolerance with standard Metformin. Results indicated that aqueous extracts of leaf and fruit possess significant hypoglycemic effect in dose dependent manner, followed by hydro-alcoholic extracts. The stem extract of *S. nigrum* has no profound effects.¹⁷

The effect of crude ethanol extract of *S. nigrum* on blood sugar of albino rat after daily oral administration of dose at the level of 250mg/kg b.wt. for five and seven days respectively. It was noticed that the chronic administration for longer duration leads to significant decrease in blood sugar compared to control. Thus it can be concluded that *Solanum nigrum* has the anti-diabetic property.²



Protective effect

Protective effect of an aqueous leaf extract of *Solanum nigrum* extract was examined against lead acetate Swiss albino mice. The oral administration of the extract for 30 days against lead acetate affected mice significantly increased the levels of antioxidants (SOD, CAT, GPx) and decreased the level of lipid peroxidation (LPO). The results of the present study, provide clear evidence of defence provided by *S.nigrum* extract against lead acetate induced toxicity in brains of albino mice.²¹

Immunostimulant activity

In this investigation found immunostimulant potential plants being an alternative for preventing fish diseases. Six groups of experimental fishes (*E. suratensis*) were immunized with 0.2ml (4ppm) of five different extracts of *Solanum nigrum* through intra-peritoneal injection and challenged with heat killed *Aphanomyces invadans*. Blood collected from immunized and normal fish were analyzed such as, radial immunodiffusion, antibody titration, nitro blue tetrazolium assay, determination of IgG concentration and host resistance test. In both control and the experimental groups the peak antibody response was on day 21 after immunization and decreased towards 28th day. The methanol extract treated group, the antibody response was significantly enhanced on the day 14 and day 21 ($p < 0.05$). The highest IgG level was on day 21 and decreased towards day 28. In Chloroform extract treated group the neutrophil activity was significantly enhanced on day 6 ($p < 0.05$). In toluene extract treated group the neutrophil activity was significantly enhanced on day 6 ($p < 0.05$). The ethanol and methanol extract treated group showed less mortality rate when compared to chloroform toluene and water extract treated group. Plants extracts have great potential as immunostimulant against microorganisms and that they can be used in the treatment of infectious diseases caused by microorganisms.²²

Antimicrobial activity

The antibacterial activity of methanol and water extracts of *Solanum nigrum* leaves was evaluated and phytochemical screening was carried out to know the compounds responsible for these activities. Methanol and water extracts were tested against *Escherichia coli*, *Staphylococcus aureus*, *Enterobacter aerogenes* and *Pseudomonas aeruginosa*. The susceptibility of the bacteria to the crude extracts on the basis of zones of growth inhibition varied according to microorganism and extracting solvent. The methanol extract produced the highest activity when compared to aqueous extract. The organisms used for the purpose of this investigation were associated with opportunistic infections in diabetic patients. On the basis of the results obtained, it could be concluded that methanol could be used for extracting antimicrobial compounds from leaves.²³

The methanol and aqueous extracts of leaves of *Solanum nigrum* L. were used for the investigation of antibacterial

studies. In antibacterial screening performed by disc diffusion method against two gram negative bacteria namely *Xanthomonas campestris* (plant pathogen) and *Aeromonas hydrophila* (animal pathogen), it was found that the methanol extracts of all the plant samples showed significant activity against the two tested bacteria. The methanol extracts of *S. nigrum* exhibited clear zone of inhibition against the tested microorganisms.²⁴

Methanolic extracts of leaves and seeds of black and red varieties of *Solanum nigrum* were tested *in vitro* for their antibacterial and antifungal activities. Antibacterial study performed against six bacteria viz., *Escherichia coli*, *Citrobacter*, *Shigella flexenari*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Yersinia aldovae* indicated that *Solanum nigrum* has potent activity against all microorganisms. The antifungal activity of these extracts was performed against six fungi, viz., *Saccharomyces cereviciae*, *Aspergillus parasiticus*, *Trichophyton rubrum*, *Macrophomina*, *Fusarium solani* and *Candida albicans*. The extracts showed moderate as well as significant activity against different fungal strains.²⁶

Preliminary results showed that dried root tissues of black nightshade extracted with 70% ethanol contained antifungal properties against *A. brassicicola*. Ethanol root extracts were used for further fractionations using ethyl acetate, n-butanol and water. Among the three extracts, the n-butanol fraction showed the strongest antifungal activity by its suppression of conidial germination of *A. brassicicola*.⁴

Ethanol methanol and ethylacetate extracts of *Solanum nigrum* leaf, seed and root were assayed for antifungal activity against fungal strains such as *Penicillium notatum*, *Aspergillus niger*, *Fuserium oxisporium* and *Trichoderma viridae*. The zone of inhibitions was compared with the standard antibiotics. Seed extracts showed antifungal activity against all the tested fungal strains compared to leaf and root extracts. Among all the extracts ethyl acetate seed extract showed high antifungal activity (8.0-16.0mm zone of inhibition) on all the tested fungal strains and relatively lowest MIC value in the range of (2.0-6.0µg/ml) were obtained with ethanol seed extracts.²⁶

Solanum nigrum was subjected to preliminary phytochemical screening activity against gram negative organism of *Escherichia coli* (NCIM: 2065) and gram positive organism of *Staphylococcus aureus* (NCIM: 2079) and they were compared with control drug Penicillin at different concentrations at 0.5, 1.0, 1.5, 2.0, and 2.5 mg/ml by disc diffusion method. In case of *Escherichia coli*, *Solanum nigrum* exhibits maximum zone of inhibition of about 30.1mm and control drug penicillin shows less activity compared to the *Solanum nigrum* plant extracts.²⁷

Six solvent extracts from leaf, seed and roots of *Solanum nigrum* were assayed for *in vitro* antibacterial activity against pathogenic bacteria such as *Bacillus subtilis*, *Bacillus megaterium*, *Staphylococcus aureus*, *klebsiella pneumonia* *E.coli*, *Proteous vulgaris*, *Pseudomonas*



putrida, and the zone of inhibition were compared with different standard antibiotics. Phytochemical screening of the crude extracts revealed the presence of secondary compounds such as alkaloids, flavonoids, steroids, tannins, and phenols. The organic solvent extracts (ethanol, methanol, ethyl acetate, diethyl ether, chloroform and hexane) of seeds were exhibited strong antibacterial activity against different pathogenic bacteria compared to leaf and root solvent extracts. The ethyl acetate seed extracts of *Solanum nigrum* exhibited strong activity against *Pseudomonas*, *Proteus vulgaris*, *Klebsiella* (20.5 – 21.0mm of zone of inhibition). Among different types of extracts tested ethyl acetate seed extract showed lowest MIC values (1.50-4.50 µg/m) against all the bacterial isolates tested. A lowest MIC value was recorded against *pseudomonas putrida*, *Proteus vulgaris*, *Klebsiella pneumonia*.²⁸

The ethanolic extract of the dried fruit of *Solanum nigrum* Linn. was assessed for its possible antimicrobial activity. The ethanolic extract showed moderate antibacterial activity against both gram-positive and gram-negative bacteria.²⁹

Ethanolic extracts of *Solanum nigrum* for antimicrobial was evaluated. The plant extract significantly inhibited the *S. aureus* and *B. subtilis* (Gram +ve) at all the tested concentrations (100, 75, 50 and 25mg/ml) as compare to standard drug Ciprofloxacin (20 µg/ml) whereas the extract failed to show inhibitory effect against *E. coli* and *P. aeruginosa* (Gram -ve) at a concentration of 25mg/ml. The extract also showed significant inhibitory effect against *C. albicans* at all concentrations except at 25mg/ml as compare to standard drug Amphotericin B (100µg/ml).³⁰

Anti-HCV activity

Methanol and chloroform extracts of *Solanum nigrum* (SN) seeds exhibited 37% and more than 50% inhibition of HCV respectively at non toxic concentration. Moreover, antiviral effect of *Solanum nigrum* seeds extract was also analyzed against HCV NS3 protease by transecting HCV NS3 protease plasmid into liver cells. The results demonstrated that chloroform extract of *Solanum* extracts decreased the expression or function of HCV NS3 protease in a dose- dependent manner and GAPDH remained constant. These results suggests that SN extract contains potential antiviral agents against HCV and combination of SN extract with interferon will be better option to treat chronic HCV.³¹

Anti-ulcer activity

The antiulcerogenic effects of the methanolic extract of *Solanum nigrum* berries on aspirin induced ulceration in rats with respect to antioxidant status in the gastric mucosa have been investigated. Oxygen free radicals are considered to be important factors in the pathogenesis of gastric ulcer. The level of lipid peroxides, which were elevated highly in rats with acute gastric mucosal injury was taken as an index of oxidative stress. The activities of

antioxidant defense enzymes were also decreased considerably by oral gastric administration of aspirin. The decreased levels of antioxidant enzymes and increased mucosal injury were altered to near normal status upon pretreatment with *Solanum nigrum* berries when compared to the ulcer induced rats. The results indicate that *Solanum nigrum* berries may exert its gastroprotective effect by a free radical scavenging action. *Solanum nigrum* berries may have considerable therapeutic potential in the treatment of gastric diseases.³²

Hepatoprotective activity

Solanum nigrum aqueous and methanolic extracts were studied for hepatoprotective activity in rats injected with 0.2 ml/kg carbon tetrachloride (CCl₄) for 10 consecutive days. *S. nigrum* aqueous extract (250 to 500 mg/kg) was administered to rats injected with carbon tetrachloride (CCl₄) for 10 days. The water extracts showed a hepatoprotective effect against CCl₄-induced liver damage, which was evident by the decrease in serum aspartate amino transferase (AST), alanine amino transferase (ALT) and alkaline phosphates (ALP) activities bilirubin concentration and by mild histopathological lesions when compared with the group of rats injected with CCl₄ alone. The methanolic extracts of *S. nigrum* (250 to 500 mg/kg) also had hepatoprotective effects with levels of serum AST, ALT, ALP and bilirubin decreasing significantly in animals treated with *S. nigrum* methanolic extract compared to an untreated group.³³

Ethanol extract of *Solanum nigrum* Linn. was investigated for its hepatoprotective activity against CCl₄-induced hepatic damage in rats. The ethanol extract showed remarkable hepatoprotective activity. The activity was evaluated using biochemical parameters such as serum aspartate amino transferase (AST), alanine amino transferase (ALT), alkaline phosphatase (ALP) and total bilirubin. The histopathological changes of liver sample in treated animals were compared with respect to control.³⁴

Antioxidant activity

The anti-oxidant activity of methanolic extract of berries of the plant *Solanum nigrum* was evaluated by tissue biochemical anti-oxidant profile. The extract exhibited significant (p<0.001) antioxidant potential as evident from the cardiac tissue biochemical antioxidant profile. The activity occurred in a dose-independent manner. The methanolic extract of berries of the plant *Solanum nigrum* possessed anti-oxidant activity.³²

The ethanolic extract of the dried fruit of *Solanum nigrum* Linn. was assessed for antioxidant and cytotoxic activity. In the qualitative antioxidant assay using DPPH (1, 1-diphenyl-2-picryl hydrazyl) the extract showed free radical scavenging properties.³⁷

Cardioprotective activity

The cardioprotective activity of methanolic extract of berries of the plant *Solanum nigrum* was evaluated by



using global *in vitro* ischemia-reperfusion injury carried out using doses of 2.5 and 5.0 mg/kg for 6 days per week for 30 days. The results indicate that the extract exhibited significant ($p < 0.001$) cardioprotective activity against global in-vitro ischemia-reperfusion injury. The activity occurred in a dose-independent manner. The methanolic extract of berries of the plant *Solanum nigrum* possessed cardioprotective activity.³⁶

Analgesic activity

Ethanollic extracts of *Solanum nigrum* for analgesic activity was evaluated. analgesic activity of the extract was evaluated for its central and peripheral pharmacological actions by using Eddy's hot plate and acetic acid induced writhing respectively. The study was carried out using doses of 100, 250 & 500 mg/kg orally. The extract showed significant analgesic activity at the dose of 500 mg/kg ($P < 0.01$) as compare to standard drug Diclofenac sodium (50 mg/kg).³⁰

The ethanollic extract of the dried fruit of *Solanum nigrum* Linn. was assessed for analgesic activity. In acetic acid induced writhing in mice, the ethanollic extract (250 and 500mg/kg) exhibited significant ($p < 0.05$ & $p < 0.01$) inhibition of writhing reflex 51.39% and 66.67% respectively compared to standard Diclofenac sodium. It shows the positive result for analgesic activity.³⁶

Antidiarrhoeal activity

The ethanollic extract of the dried fruit of *Solanum nigrum* Linn. was assessed for antidiarrhoeal activity. The fruit extract showed a significant ($P < 0.01$ and $P < 0.001$) antidiarrhoeal activity against castor oil induce diarrhoea in mice in which it decreased the frequency of defecation and increased the mean latent period at the dose of 250mg/kg and 500mg/kg body weight.³⁶

Cytotoxic activity

The ethanollic extract of the dried fruit of *Solanum nigrum* Linn. cytotoxic activity. In the brine shrimp lethality test, the extract showed cytotoxicity significantly with $LC_{50} = 63.10 \mu\text{g/ml}$ and $LC_{90} = 160 \mu\text{g/ml}$ ³⁶

Larvicidal activity

The larvicidal activities of crude and solvent extracts of *Solanum nigrum* L. leaves against *Culex quinquefasciatus*. The results indicated that the mortality rates at 0.5% concentration were highest amongst all concentrations of the crude extracts. Result of log probit analysis (at 95% confidence level) revealed that lethal concentration LC_{50} and LC_{90} values gradually decreased with the exposure periods in bioassay experiment with the crude plant extract. The results of regression analysis of crude extract of *S. nigrum* revealed that the mortality rate is positively correlated with the concentration of the extracts. Results of this analysis showed that the ethyl acetate extract of *S. nigrum* may be considered as a potent source of a mosquito larvicidal agent.³⁷

Anti-inflammatory activity

The methanolic extract of whole plants of *Solanum nigrum* L. was investigated for anti-inflammatory activity on the experimental animal models. The methanolic extract at a concentration of 100 mg/kg b.w and 200 mg/kg b.w showed the significant dose dependent anti-inflammatory activity in carrageenin and egg white induced hind paw oedema in rats. The standard drugs were Indomethacin (10 mg/kg) and Cyproheptadine (8 mg/kg).³⁸

Ethanollic extracts of *Solanum nigrum* for anti-inflammatory was evaluated by using Carrageenan-induced rat paw edema. The study was carried out using doses of 100, 250 & 500 mg/kg orally. Anti-inflammatory activity at the dose of 500 mg/kg ($P < 0.01$) as compare to standard drug Diclofenac sodium (50 mg/kg).³⁰

The effect of methanolic extracts of berries of *Solanum nigrum* were studied on carrageenan induced paw edema. The methanolic extract decreased the edema induced in hind paw. The methanolic extract of *Solanum nigrum* (375 mg/kg b.w.) has showed significant anti-inflammatory.³⁹

Anticancer activity

The anticancer activity of the fruits of *Solanum nigrum* on the HeLa cell line. The fruits of *Solanum nigrum* methanolic extract were tested for its inhibitory effect on HeLa Cell Line. The percentage viability of the cell line was carried out by using Trypan blue dye exclusion method. The cytotoxicity of *Solanum Nigrum* on HeLa cell was evaluated by the SRB assay and MTT assay. *Solanum Nigrum* methanolic extract has significant cytotoxicity effect on HeLa Cell Line in concentration range between 10 mg/ml to 0.0196 mg/ml by using SRB assay.⁴⁰

Anti-seizure activity

Aqueous extract of the leaves of *S. nigrum* was evaluated for anti-seizure activity in chicks, mice and rats by intra-peritoneal administration of the extract. At a pre-treatment time of 30 minutes and, at graded doses and animals were challenged with different types of proconvulsants. The result was that aqueous leaf extract produced a significantly ($P < 0.05$) dose dependent protection against electrically-induced seizure in chicks and rats, pentylenetetrazole-induced seizure in mice and rats and picrotoxin-induced seizure in mice and rats. The anti-seizure property of the extract was potentiated by amphetamine.⁴¹



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