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A Review of *Solanum Nigrum* Linn's Pharmacological Properties

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Abstract

Dementia, This article aims to reconcile the traditional usage of Solanum Nigrum linn. (Sn) in folklore with the findings of evidence-based investigations. Despite containing the harmful toxin solanine, Sn has shown significant promise as a source of antioxidants with hepatoprotective, anti-tumor, cytostatic, anti-convulsant, anti-ulcerogenic, and anti-inflammatory properties. The review includes research conducted on Sn using in-vitro, in vivo, and clinical approaches. It assesses whether appropriate scientific methods have been used to provide experimental evidence supporting its traditional usage. This evaluation would provide research scientists with an opportunity to ascertain the extent of knowledge and identify any remaining gaps in the examination of Sn.

Key words: Solanum Nigrum, folklore medicine, anticancer, solanine

Introduction

Solanum Nigrum Linn., sometimes referred to as Black Nightshade, is a dicot weed belonging to the Solanaceae family. This African herb is used in the treatment of several conditions that contribute to newborn mortality, including fever-induced convulsions. Sn is a perennial plant with branches that grows up to a height of 90 cm. It has dark green leaves that are dull in appearance. The leaves are juicy and have an ovate or lanceolate shape. The edges of the leaves are either toothless or slightly toothed. The flowers are little and have a pale hue, including a concise pedicellate and five petals that are widely dispersed. The fruits are little and assume a dark hue as they reach maturity (Cooper and Johnson, 1984). S. nigrum primarily inhabits areas such as wasteland, abandoned fields, ditches, roadsides, fence rows, woodland borders, and cultivated land. This plant is widespread across Europe and Africa. *Solanum Nigrum* (Sn) is a widely favoured plant primarily because of its high levels of Solanine, a poisonous glyco-alkaloid present in many portions of the plant, with the greatest quantities found in the unripe berries (Cooper and Johnson, 1984). Despite being recognised as a valuable source of one of the most widely used plant toxins, it has also been shown to contain a variety of phytochemicals that have potential for use in medicine (Lee and Lim, 2006). The objective of this study is to systematically compile the scientific literature about the pharmacological properties of Sn.

CHEMICAL CONSTITUENTS

Various chemicals have been extracted from various portions of Sn that have shown pharmacological significance in relation to the reported effects of the whole plant preparation of Sn. In their study, Sun *et al.* (2006) documented the fluctuation in the levels of organic acids in both Sn seedlings and adult plants. The primary organic acids found in Sn were acetic acid, tartaric acid, malic acid, and citric acid. Tartaric acid and citric acid, on the other hand, were identified as the most crucial

compounds for Sn's adaptive responses to environmental stressors. Solanine, a glycoalkaloid, is present in significant amounts throughout the various portions of Sn. However, the largest quantities are found in the unripe berries of Sn. Nevertheless, after the berries are fully mature, they become the least poisonous portion of the plant and are sometimes consumed without any harmful consequences. Furthermore, the concentration of solanine in the leaves of the plant rises as it reaches maturity (Cooper and Johnson, 1984). The compound known as solanine, seen in Figure 1, may be divided into six distinct components using chromatography. These components are referred to as alpha, beta, and gamma chaconines, as well as alpha, beta, and gamma solanines (Merck, 1989). Solanidine (C27 H43 NO; MW = 397.62) is derived from the hydrolysis of solanine and solanine, and it has lower toxicity. Bhat *et al.* (2008) also observed that the formation of a steroidal alkaloid called solasodine is influenced by the level of salt. This alkaloid has a similar structure to the one shown in Figure 2. Eltayeb *et al.* (1997) showed that the concentration of the steroidal alkaloid solasodine was greatest in the leaves. However, according to some sources, the distribution of Solasodine is as follows: 9.93 mg g-1 in roots, 6.10 mg g-1 in stems, 4.06 mg g-1 in leaves, and 0.61 mg g-1 in fruits. The total alkaloid content per leaf grew as the leaves developed, whereas the concentration of alkaloids decreased. The little unripe fruits of S. nigrum contain a significant quantity of solasodine. However, as the fruits mature, both the concentration and the absolute amount of solasodine per fruit drop. Studies indicate that the alkaloid concentration of different areas of the plant undergoes variations as Sn develops. Nitrates and nitrites are present in varying quantities in black nightshade and may contribute to its poisonous properties (Cooper and Johnson, 1984). Hu *et al.* (1999) identified and separated three steroidal glycosides with anti-cancer properties: beta 2-solamargine, solamargine, and degalactotigonin.

Studies on Sn through spectroscopic analysis, chemical degradation and derivitisation led to the identi- fication of six new steroidal saponins collectively called solanigrosides and a one known saponin degalacto- tigonin (Zhou *et al.*, 2006). Similarly, any set of two steroidal saponin known as nigrumins I and II were characterised from Sn. Nigrumnin I was established as (25R)-5alpha-spirostan-3beta-ol 3-O-betaD-xylopyranosyl- (1-->3)-[alpha-L-arabinopyranosyl-(1 –>2)]- beta-D-glucopyranosyl-(1-->4)-[alpha-L-rhamnopyranosyl(1-->2)]-beta-D-galactopyranoside (1), and nigrumnin II was elucidated as (25R)-3beta, 17alpha-dihydroxy-5alpha-spirostan-1 2-one 3-O-beta-D- xylopyranosyl-(1-->3)- [alpha-L-arabinopyranosyl-(1-->2)]-beta-D-glucopyranosyl- (1-->4)-[alpha-L-rhamnopyra-nosyl-(1-->2)l-beta-D-galac- topyranoside.

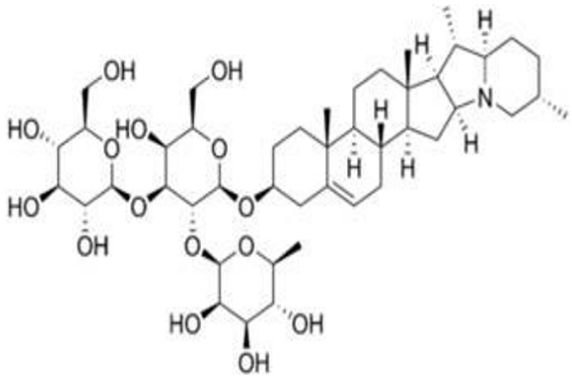

Figure 1: Solanine

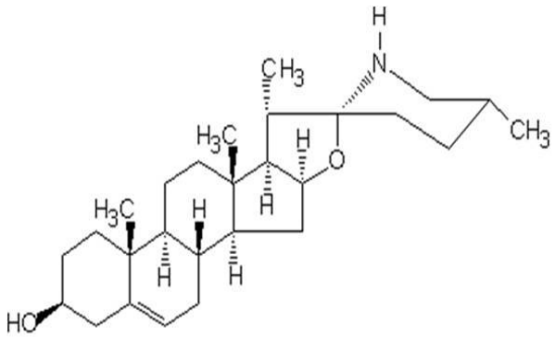

Figure 2: Solasodine

Also, five non-saponin namely 6-methoy-hydroxycoumarin, syringaresinol-4-O-beta-D-glucopyran- oside, pinoresinol-4-O-beta-D-glucopyranoside, 3, 4-dihy- droxhbenzoic acid (IV), p-hydroxybenzoic acid and 3- methoxy-4-hydroxyienzoic acid were isolated for studies by Wang *et al.* (2007)

Schmidt and Baldwin (2007) found that Sn generates Sysytemin, an 18 amino acid polypeptide that resembles the systemic wound response protein produced by tomatoes. A cDNA of 910 base pairs (bp) was recently

isolated. It encodes an osmotin-like protein with an open reading frame of 744 bp, which produces a protein consisting of 247 amino acids (26.8 kilodaltons). The cDNA was cloned from S. nigrum (SniOLP) by Jami *et al.* in 2007. The phylogenetic research demonstrated that this protein is conserved across several species within a small multigene family, and it exhibits expression unique to certain organs. The upregulation of this protein has been shown to be induced by osmotic and oxidative stressors.

Researchers have identified one spirostanol glycoside and two furostanol glycosides in a methanol extract obtained from the stems and roots of S. nigrum (Sharma *et al.*, 1983). Quercetin is considered to be one of the strongest natural antioxidants. Sn includes two quercetin glycosides, namely quercetin 3-O-(2Gal-α-rhamnosyl)-β-glucosyl (1→6)-β-galactoside and quercetin 3-O-α-rhamnosyl(l→2)-β-galactoside. In addition, Nawwar *et al.* (1989) also discovered quercetin 3-glucosyl(l→6)galactoside, 3-gentiobioside, 3-galactoside, and 3-glucoside, which were previously recognised. Recent phytochemical research of S. nigrum has led to the discovery of two new disaccharides. Their structures were identified as ethyl β-d-thevetopyranosyl-(1→4)-β-d-oleandropyranoside and ethyl β-d-thevetopyranosyl-(1→4)-α-d-oleandropyrano-side, respectively, using chemical and spectroscopic techniques (Chen *et al.*, 2009).

The berries of S. nigrum have been discovered to contain a saturated steroidal genin, specifically identified as tigogenin using mixed melting point and i.r. spectroscopy (Varshney and Sharma, 1965). A 150-kDa glycoprotein was extracted from S. nigrum, a plant that has been traditionally used in folk medicine as a treatment for fever and cancer. The SNL glycoprotein is composed of 69.74% carbohydrates and 30.26% proteins. It includes over 50% hydrophobic amino acids, including glycine and proline (Lee and Lim, 2006).

While plants include hazardous elements in various parts, research on the nutritional value of leaves and seeds has shown that Sn is beneficial for nutrition, even if it may contain certain anti-nutritive substances such as oxalate. The protein content of the leaves and seeds was determined to be 24.90% and 17.63%, respectively. The leaves and seeds have ash contents of 10.18% and 8.05% respectively. The crude fibre contents are 6.81% and 6.29% for the leaves and seeds respectively. The carbohydrate contents are 53.51% and 55.85% for the leaves and seeds respectively.

Mineral analysis revealed the magnitude of presence in 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/100 g in the leaves and 62.50 and 14.48, g/100g in the seeds. Vitamin content indicate the order of mag- nitude as 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.

ANTICANCER PROPERTIES

The impact of the crude polysaccharide derived from S. nigrum linn. (SNL-P) was assessed by experiments conducted in both living organisms and laboratory settings, specifically targeting U14 cervical cancer cells. While SNL-P did not exhibit any inhibitory impact on cell proliferation in vitro at dosages up to 1 mg/ml, it did reduce the number of ascites tumour cells and the survival time of U14 cervical cancer-bearing mice that received doses ranging from 90 to 360 mg/kg bw orally. Flow cytometric examination using a FACScan instrument revealed that the majority of the tumour cells in the ascites sample were in the G2/M phase of the cell cycle. This may be regarded as the fundamental foundation for its use as an anticancer agent (Jian *et al.*, 2009). In a previous study conducted by Jian *et al.* (2007), the researchers investigated the impact of a 12-day oral administration of SNL-P on cervical cancer (U14) in mice. The results revealed a notable inhibition of tumour growth, accompanied by an increase in the expression of Bax and a decrease in the expression of Bcl-2 and mutant p53. These changes were positively associated with the number of tumour cells undergoing apoptosis. In addition, SNL-P therapy resulted in a reduction in the

concentration of TNF-α in the bloodstream, which is associated with the initiation of apoptosis in cancer cells. The results indicated that the SNL-P has the potential to be used as an anticancer drug, as shown by Jian *et al.* in 2007. An Lei *et al.* (2006) review indicates that Sn's ability to disrupt the structure and function of tumour cell membranes, hinder DNA and RNA synthesis, alter cell cycle distribution, inhibit the anti-apoptotic pathway of NF-kappaB, activate caspase cascades, and enhance nitric oxide production contribute to its anticancer potential. The role of autophagic cell death in the anticancer mechanisms of Sn was thoroughly investigated using LC3-I and LC3-II proteins in Hep G2 cells. The results demonstrate that the presence of Sn in cells leads to autophagy and vacuolization in a manner that is dependent on its concentration. This may provide an advantage in the treatment of liver-specific malignancy.

A case-control research was conducted to investigate the impact of nutritional and social variables on a group of 130 patient/control pairs. The pairs were carefully selected to ensure that they were similar in terms of age, gender, and educational level. The study analysed the staple diet, intake of wild vegetables, usage of tobacco, and traditional beer drinking between the two groups. S. nigrum includes protease inhibitors that may promote the growth of cells in the oesophagus and perhaps lead to the development of cancer (Sammon, 1998)

The MTT test was used to assess the anti-tumor activity of solanine, a steroid alkaloid derived from the nightshade plant, on three digestive system tumour cell lines: HepG(2), SGC-7901, and LS-174. The concentration of solanine required to achieve a particular IC (50) score was 14.47 microg/ml for HepG (2) cell line, more than 50 microg/ml for SGC-7901 cell line, and greater than 50 microg/ml for LS-174 cell line. Additionally, evidence of apoptosis were seen. Similar effects may be seen in other cancer cell lines, such as the Chang liver and WRL-68 cells (Lin *et al.*, 2007), but to a lesser extent. The treated groups exhibited a decrease in the number of cells in the G(2)/M phases, while there was a large rise in the number of cells in the S phase. This increase in the S phase cells led to a reduction in the expression of the Bcl-2 protein. Thus, it seems that solanine's effect on causing apoptosis in HepG (2) cells is achieved via inhibiting the production of Bcl-2 protein (Ji *et al.*, 2008). There seems to be a distinct reaction in how cells die when exposed to either high or low quantities of SNE. At high levels, the SNE (50-1000 μg/ml) caused cell death by apoptosis, which included the release of cytochrome c from mitochondria and activation of caspases. At low concentrations, SNE induced autophagocytic death, which was characterised by morphological and ultrastructural alterations. In addition, these cells exhibited elevated quantities of autophagic vacuoles and proteins LC3-I and LC3-II, as well as distinctive hallmarks of autophagy. Collectively, our results demonstrate that SNE causes cell death in hepatoma cells by two separate antineoplastic mechanisms: the capacity to trigger apoptosis and autophagocytosis. This implies that SNE might be a potential treatment option for liver cancer (Lin *et al.*, 2007).

Additionally, the anticancer efficacy of the aqueous portion of Sn was assessed in vivo. This closely imitates the process of preparing plants in traditional medicine. The aqueous extract of S. nigrum (SNL-AE) suppressed the development of U14 cervical cancer and enhanced the count of CD4+ T lymphocyte subsets, along with increasing the ratio of CD4+/CD8+ T lymphocytes. Additionally, it reduced the count of CD8+ T lymphocyte subsets and PCNA positive cells in tumor-bearing mice. In addition, SNL-AE was shown to halt the cell cycle in the G0/G1 phase and trigger death of a greater number of transplanted tumour cells in a way that depended on the dosage. This indicates that the anti-tumor properties of SNL-AE are linked to its ability to modulate the immune system (Jian *et al.*, 2008). Several studies have shown that Sn enhances the resistance of cancer cells to oxidative stress, resulting in anticancer activity.

An isolated glycoprotein (150kDa) rich in proline and glycine, derived from Sn, shown modulatory effects on transcriptional factors (NF-kappa B and AP-1) and iNO synthesis. This, in turn, resulted in an enhancement of NO production in MCF-7 cells (Heo *et al.*, 2004;

Son *et al.*, 2003; Lim, 2005). This glycoprotein clearly induces the release of cytochrome C from the mitochondria, leading to the activation of caspases and ultimately resulting in the death of tumour cells. Lunasin, a peptide consisting of 43 amino acids and weighing 4.8 kDa, was first discovered in soybeans and has now been detected in Sn. By decreasing the phosphorylation of retinoblastoma protein (Rb) and the acetylation of core histone H3 and H4, it induces anticancer effects and cell-cycle arrest (Jeong *et al.*, 2008). Anti-angiogenesis is a well-established mechanism used by many chemotherapeutic medicines to inhibit the growth of new blood vessels, which is crucial for the development and spread of tumours. Sn demonstrated anti-angiogenic effects on the chick chorioallantoic membrane, as reported by Xu *et al.* in 2008.

IMMUNOMODULATORY EFFECTS

In vivo experiments showed that the ratio of CD4+/CD8+ peripheral blood T-lymphocyte subpopulations were restored following the treatment of SNL-P. Furthermore, treatment with SNL-P also caused a significant increased in IFN-α ($p < 0.01$, 90, 180 and 360 mg/kg bw) and a remarkable decrease in IL-α ($p < 0.01$, 90, 180 mg/kg b.w.; $p < 0.05$, 360 mg/kg b.w.) measured by the method of ELISA.

These data showed that SNL-P possess potent antitumor activity and SNL-P might exert antitumor activity via activation of different immune responses in the host rather than by directly attacking cancer cells on the U14 cervical cancer bearing mice. Thus, SNL-P could be used as an immunomodulator (Jian *et al.*, 2009).

ANTIMICROBIAL, NEMATICIDAL AND MOLLUSCICIDAL PROPERTIES

The activity of root extracts from black nightshade (S. nigrum) against isolates ABA-31 and ABA-104 of Alternaria brassicicola, the causative agent of black leaf spot of Chinese cabbage (Brassica pekinensis), was analysed. The dried root tissues of black nightshade include methanolic extracts that have antifungal activities specifically targeting A. brassicicola. Subsequent separation and evaluation of the ethyl acetate, n-butanol, and water fractions of root extracts revealed that the n-butanol extract exhibited the highest level of potency in terms of antimicrobial activity. The active components responsible for the antibacterial actions on Sn were identified as saponins (Muto *et al.*, 2006). In their 2007 study, Afaf and Soad examined the impact of a sub-lethal concentration (LC25) of Sn leaves on the mollusc Biomphalria arabica in Saudi Arabia. They found that the activities of AST, ALT, and LDH were changed in the molluscs, which may indicate the mechanism behind its molluscicidal properties. In a study conducted by Amer and Manal in 2005, they found that combining Sn and Iris pseudacorus in a binary form had a significant molluscicidal effect on Biomphalaria alexandrina, as well as a cercaricidal effect on Schistosoma mansoni cercariae. This finding is consistent with the results reported by Ahmed and Ramzy in 1998. A study conducted by Amer and Manal in 2005 investigated the impact of a 30-minute pre-treatment of mice with different concentrations (ranging from 2.5 to 10 mg/ml) of a crude water extract of Sn on the ability of S. mansoni cercariae to penetrate and infect. The results indicated a substantial decrease in both penetration ($p < 0.001$) and infectivity ($p < 0.01$) of the cercariae. In addition, a recent study conducted by Raghavendra *et al.* (2009) and Ahmed *et al.* (2002) evaluated the effectiveness of Sn extracts as a larvicidal agent against five mosquito species that were bred in laboratory conditions.

ANTIOXIDANT PROPERTIES

There is evidence that several clinical conditions, including both communicable and non-communicable illnesses, are linked to oxidative stress.

Therefore, it is important to include powerful antioxidants in our diet and medication supplements. A research examining the impact of six different pretreatment procedures on the peroxidase activity, chlorophyll levels, and antioxidant status of S. nigrum L. found that these approaches had a significant influence ($p < 0.05$) on the measured parameters. A significant disparity in the levels of carotenoids, phenolics, flavonoids, and tannins has been documented, highlighting the vulnerability of

this antioxidant found in Sn (Adebooye *et al.*, 2008). The SNL glycoprotein had a radical scavenging activity that was dependent on the dosage. It effectively scavenged many types of radicals, such as 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radicals, hydroxyl radicals (OH), and superoxide anions (O−).

Sn, although functioning as an anti-tumor agent, may promote apoptosis in HT-29 cells by inhibiting the activation of NF-kB caused by oxidative stress. This effect is mediated via the SNL glycoprotein (Heo *et al.*, 2004). The hydroxyl radical scavenging capacity of a 50% ethanol extract from the whole S. nigrum plant has been observed, indicating a possible cytoprotective mechanism (Kumar *et al.*, 2001; Mohamed *et al.*, 2007). The antioxidant capacity of Sn leaves was evaluated in the modification of a 6-hour restraint-induced oxidative stress. The results show that Sn was more effective as an antioxidant when administered after the restraint, compared to when administered before the restraint.

ANTI-CONVULSANT ACTIVITY

The central nervous system depressive activity of Sn was determined by assessing the impact of intraperitoneal injection of Sn on several neuropharmacological parameters. Sn fruit extracts substantially increased the duration of sleep induced by pentobarbital, caused changes in overall behaviour, decreased exploratory behaviour, inhibited aggressive behaviour, impacted movement, and reduced spontaneous activity. This supports its use as an anti-convulsant and is consistent with its action similar to acetylcholine (Perez *et al.*, 1998). The effectiveness of Sn in treating baby convulsions is extensively acknowledged in African paediatric care. In their study, Wannang *et al.* (2008) examined the anticonvulsant properties of S. nigrum leaves in chicks, mice, and rats.

The animal subjects were protected against several kinds of proconvulsants after receiving a 30-minute pretreatment of Sn leaf extract by intraperitoneal injection. The leaf extract dissolved in water demonstrated a dose-dependent protective effect against seizures generated by electrical stimulation in chicks and rats, seizures induced by pentylenetetrazole in mice and rats, and seizures induced by picrotoxin in mice and rats. This effect was shown to be statistically significant ($p < 0.05$) according to a study conducted by Wannang *et al.* in 2008. De Melo *et al.* (1978) were the pioneers in providing empirical evidence that supports the assertion of Sn's acetylcholine-like properties. Their conclusion was derived from the observation of the following effects: The effects observed in this study include: 1) Isotonic contraction of the isolated toad rectus abdominis muscle; 2) Negative chronotropic and inotropic action on the isolated toad heart; 3) Isotonic contraction of the isolated guinea pig's ileum; 4) Isotonic contraction of the rat's isolated jejunum; 5) Decrease in arterial blood pressure in the cat; 6) Secretory effects on the rat's submaxillary gland. The fruits of Sn were discovered to contain chemicals with cholinergic action, reaching levels of up to 250 micrograms per gramme of fruit (de Melo *et al.*, 1978).

HEPATOPROTECTIVE EFFECTS

S. nigrum L. (SN) is a medicinal plant that has been used in Chinese medicine for its hepatoprotective and anti-inflammatory properties. Sprague-Dawley (SD) rats were given different doses of SNE (0.2, 0.5, and 1.0 g kg-1 bw) orally, coupled with the administration of CCl4 (20% CCl4/corn oil; 0.5 mL kg-1 bw), for a duration of 6 weeks. The results showed that Sn exhibited hepatoprotective effects against CCl4. The experimental medicine effectively reduced the increase in hepatic enzyme markers (GOT, GPT, ALP, and total bilirubin) caused by CCl4, and also decreased the production of superoxide and hydroxyl radicals compared to the group treated with CCl4 alone (Raju *et al.*, 2003). According to Lin *et al.* (2008), liver histology demonstrated that SNE decreased the occurrence of liver abnormalities caused by CCl4 in rats. These abnormalities included hazy swelling of hepatic cells, infiltration of lymphocytes, hepatic necrosis, and proliferation of fibrous connective tissue. Previous research has shown that the administration of SNE (at doses of 0.2 or 1.0 g/kg) by gastrogavage for a period of 12 days may reduce the effects of liver fibrosis induced by thioacetamide (TAA) and other substances that are harmful to the liver. SNE decreased the levels of hepatic

hydroxyproline and α-smooth muscle actin proteins in mice treated with TAA. SNE suppressed the expression of collagen (α1) (I) and transforming growth factor-β1 (TGF- β1) mRNA in the liver, as shown in studies conducted by Hsieh *et al.* (2008) and Sultana *et al.* (1995).

In another research conducted by Hsu *et al.* (2009), 2-acetylaminofluorene was used as a substance to cause the development of liver cancer. The presence of Sn suppressed the development of liver cancer, as shown by the elevated levels of glutathione S-transferase-alpha and -mu, transcription factor Nrf2, glutathione peroxidase, superoxide dismutase-1, and catalase (Hsu *et al.*, 2009). Aflatoxin B1-induced liver cancer is a prevalent cause of hepatocarcinogenesis in Africa. The activation of several cytochrome p450 systems and the suppression of phase II enzyme expression, which are responsible for AFB1 metabolism, prevent its toxicity. Sn enhanced the enzymatic activity of uridine diphosphate glucuronyltransferase (UDPGT) and glutathione S-transferase in female rats exposed to AFB1 (0.2 or 0.4 mg/kg bw) toxicity, according to a study by Moundipa and Domngang in 1991.

ANTIULCEROGENIC AND ANTI-INFLAMMATORY EFFECTS

Sn is suggested in ayurveda for treating stomach ulcers. Therefore, it is crucial to determine the mechanism behind its anti-ulcerogenic activity. Rats were subjected to several forms of stress (such as cold restraint stress, indomethacin, pyloric ligation, ethanol, and acetic acid) in order to generate stress ulcers. The extract of Sn fruits shown a considerable inhibition of gastric lesions generated by 76.6%, 73.8%, 80.1%, and 70.6%, respectively. Its efficacy was equivalent to or greater than that of omeprazole. A study conducted by Akhtar and Munir in 1989 found that Sn extracts resulted in a simultaneous reduction in stomach secretory volume, acidity, and pepsin production in rats with ulcers. Furthermore, the administration of SNE at doses of 200 and 400 mg/kg body weight resulted in an expedited healing process of ulcers caused by acetic acid, after a 7-day treatment period. Enzymatic investigations on the activity of H+K+ATPase to determine the antisecretory effect revealed that SNE effectively inhibits H+K+ATPase activity and reduces gastrin secretion in an ulcer model generated by EtOH. The histological analysis showed that the use of SNE resulted in a decrease in the size of the ulcer, as reported by Jainu *et al.* in 2006. Zainul *et al.* (2006) have presented data indicating the potential of Sn to reduce inflammation and provide pain relief. Recently, the effectiveness of the 150 kDa glycoprotein of Sn in preventing colitis produced by dextran sodium sulphate in A/J mice was assessed. Sn was shown to have inhibitory effects on the levels of nitric oxide generation, lactate dehydrogenase release, and thiobarbituric acid reactive compounds. This is accomplished by controlling the activity of transcription factors like NF-kappaB (p50) and AP-1 (c-Jun). Additionally, Sn controls the production of iNOS and COX-2, which are key enzymes involved in pathways that trigger inflammatory responses.

HYPOLIDEAMIC, ANTI-HYPERGLYCEMIC AND HYPOTENSIVE POTENTIALS

Hyperlipidemia is a significant contributing factor to cardiovascular diseases. Atherosclerosis and other types of cardiovascular dysfunction are caused by overstimulation of the cation pumps located on the cell membranes. Given that Sn has inhibitory effects on the H+K+ATPase, it is plausible to consider it as a potential cardioprotective treatment. The study aims to examine the effects of a 150 kDa glycoprotein isolated from S. nigrum Linn. (SNL) on lipid linked diseases. This glycoprotein has been traditionally utilised in folk medicine as a hepatoprotective and anticancer agent. Mice that received Sn treatment exhibited reduced levels of plasma lipoproteins, including triglycerides (TG), total cholesterol (TC), and low-density lipoprotein (LDL). Furthermore, the SNL glycoprotein suppresses the function of hepatic HMG-CoA reductase produced by cholestyramine at a dosage of 40 µg/g head body weight (Lee *et al.*, 2005). The ethnobotanical use of the leaves of S. nigrum Linn. (Solanaceae), Vitex negundo Linn. (Verbenaceae), and stems of Nopalea

cochinellifera (Linn.) as anti-diabetic agents was validated using the oral glucose tolerance test. The results indicated that S. nigrum did not significantly lower blood glucose levels (Villaseñor and Lamadrid, 2006).

The antipyretic and anticancer characteristics of Sn, which has been traditionally utilised in folk medicine, were examined in relation to its potential as an antihypertensive agent. The glycoprotein isolated from Sn has a molecular weight of 150 kDa and is composed of carbohydrates (69.74%) and protein (30.26%). It contains a high proportion of hydrophobic amino acids, such as glycine and proline, which effectively inhibit the activation of nuclear factor-kappa B (NF-kB) and reduce the production of inducible nitric oxide (iNO) in vitro. These effects were observed at a concentration of 40 µg/ml, as reported by Lee and Lim in 2006.

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