Solanum violaceum Ortega, a promising medicinal plant

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ABSTRACT

The medicinal plant, Solanum violaceum Ortega (Family: Solanaceae) is mainly used as a vegetable. It is widely distributed in Bangladesh. The whole plant or different parts of the plant have been used over the years for the remedy of a number of diseases such as headache, fever, indigestion, asthma, diabetes and ulcers etc. In the recent years, a number of scientific evidences on its traditional usage have been seen along with the bioactivity evaluation of its isolated phytochemicals. This review offers a current scenario of the S. violaceum, emphasized on the phyto-pharmacological findings. For this purpose, a search was made in the electronic databases: PubMed, Science Direct and Google Scholar for the published articles till November, 2017. The results suggest that a number of important steroidal sapogenins and glycosides along with other steroids have been isolated from this plant. S. violaceum possesses promising biological activities, including anti-nociceptive, anti-pyretic, wound healing, anthelmintic, anti-microbial, anti-inflammatory, anti-oxidant and cytotoxicity. In conclusion, S. violaceum may be a promising source of lead compounds.

Keywords: Solanum violaceum, ethnobotanical usage, phytochemicals, bioactivities.

INTRODUCTION

According to World Health Organization (WHO), plant species have been found to serve as one of the important sources of modern medicines (approximately, 25%) (Islam et al., 2016). A continuous search is being made for the discovery of novel molecules to be used in the treatment of various diseases or to improvise existing therapy suggesting plants are always an interesting and promising source of drugs.

The medicinal plant, Solanum violaceum belonging to the Solanaceae family is basically used as a vegetable. It is known in Bengali as 'Phutki', 'Tit Begun', 'Brihati Begun', 'Baikur'. The Marma tribe calls it 'Pokhonghesi', while 'Titbahal' by the Garo tribe in Bangladesh. 'Poison Berry' and 'Indian Night Shade' are the English names of the plant. It is widely distributed throughout the country (Bangladesh) on forest edges, road sides and fallow lands (Karim et al., 2017; MPB, 2017).

This review provides a profile on the botanical, phytochemical and biological activities of S. violaceum.

METHODOLOGY

Stratagem

A search was made in the PubMed, Science Direct and Google Scholar databases with the keyword ‘Solanum violaceum Ortega’, which was then paired with ‘morphology’, ‘traditional/ethno-pharmacological uses’, ‘phytochemicals’ and ‘pharmacological activities’ (Figure 1). The obtained evidences were included and excluded as:

Inclusion criteria including:

- In vitro, ex vivo and in vivo studies on S. violaceum;
- Phytochemical and/or pharmacological reports on S.
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A B C
F D E

Figure 1: Solanum violaceum Ortega (A: Aerial parts, B: Flowering stalk, C: Flower, D: Un-ripe fruit, E: Mature and ripe fruits, F: Seeds). Box 1: Pant taxonomy (Bhutan Biodiversity Portal, 2017). Botanical name: Solanum violaceum Ortega; Kingdom: Plantae; Phylum: Tracheophyta; Class: Magnoliopsida; Order: Solanales; Family: Solanaceae; Genus: Solanum; Species: Solanum violaceum Ortega.

violaceum;
- Reports on extract(s) or isolated compound(s) and their activities.

Exclusion criteria including:
- Data not related to the focusing study;
- Reports on other species of Solanum genus;
- Data duplication.

RESULTS

To date, a total of 781 articles were found in the aforementioned databases. After exclusion, 19 were included in this study.

Plant morphology

S. violaceum is a medium sized shrub with raft branches provided with curved prickles. The height of the plant varies from 0.3 to 1.5 m. Hairy leaves appear to be 5 to 15 cm long, ovate in outline, acute, sub-entire or with a few large triangular-ovate subacute lobes and sparsely pricked on both sides. Pale purple flowers in racemose are extra-exillary cymes, while corolla is 8 mm long. Berry is 8 mm in diameter and becomes dark yellow when ripe (MPB, 2017).

Traditional usages

Table 1 shows a number of traditional uses of S. violaceum reported.

Chemical constituents of S. violaceum

S. violaceum contains alkaloids, carbohydrates, di-terpenes, flavonoids, glycosides, gums, phenols, proteins, saponins and tannins (Karim et al., 2017; Raju et al., 2013). Total phenolic content of methanolic extract of S. violaceum was found to be 54.67 gallic acid equivalent (GAE) per gram of dry extract (Raju et al., 2013).

Fruits contain 1.8% steroidal alkaloids, while the leaves and roots contain steroidal alkaloids, solanine, solanidine and solasodine (Ghani, 2003; Thongchai et al., 2010). To date, a number of steroidal sapogenins isolated from the aerial parts of S. violaceum include indioside L, indioside M, indioside N and indioside O. Other steroids isolated from the plant are: (22E, 24R)-5α, 8α-epidioxyergosta-6,22-dien-3β-ol, (22E, 24R)-5α,8α-epidioxyergosta-6,9(11), 22-trien-3β-ol, 7-oxostigmasterol, 7-oxositosterol, diosgenin, yamogenin, diosgenone and (25S)-neospirost-4-en-3-one. A lignin (for example, syringaresinol) and a coumarin (for example, scopoletin) were also reported in this plant (Chang et al., 2013).

Steroidal glycosides, indioside G to K and some other molecules such as borassoside D, yamogenin 3-O-α-L-rhamnopyranosyl-(1→2)-β-D-glucopyranoside, borassoside E, 3-O-chacotriosyl-25(S)-spirost-5-en-3β-ol, sitosterol 3-O-β-D-glucopyranoside, 7-hydroxysitosterol-3-O-β-D-glucopyranoside, N-p-coumaroyltyramine, trans-N-feruloyloctopamine and tricalysioside U were also isolated.
Table 1: Traditional use of *S. violaceum*.

<table>
<thead>
<tr>
<th>Plant parts/mode of use</th>
<th>Ailments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf juice ginger juice</td>
<td>Vomiting, Parasitic worm infestation, constipation, indigestion, pruritus, leucoderma and asthma</td>
<td>(Karim et al., 2017)</td>
</tr>
<tr>
<td>Fruits</td>
<td>Asthma, dry cough, catarrh, colic, flatulence, worms, dysuria, toothache, nasal ulcers and fever</td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>Vomiting and indigestion</td>
<td>(Malek et al., 2012)</td>
</tr>
<tr>
<td>Root paste/twice daily</td>
<td>Headache, pain in the head</td>
<td>(Seraj et al., 2013)</td>
</tr>
<tr>
<td>Macerated leaves, fruits and juice/applied to the head (twice daily for one to two hours and the treatment is continued for a period of seven days)</td>
<td>Headache, pain in the head</td>
<td>(Seraj et al., 2013)</td>
</tr>
<tr>
<td>Fruits</td>
<td>Diabetes</td>
<td>(Raghavendra et al., 2015)</td>
</tr>
<tr>
<td>Whole plant</td>
<td>Asthma, dry cough and chronic febrile infections</td>
<td>(Quamar and Bera, 2014)</td>
</tr>
<tr>
<td>Little bit of fruit powder/ added in a glass of milk and then kept in mouth for a while</td>
<td>Toothache</td>
<td>(Kokni et al., 2016)</td>
</tr>
<tr>
<td>Root paste/external application</td>
<td>Poison</td>
<td>(Thomas and Rajendran, 2013)</td>
</tr>
<tr>
<td>Aqueous root extract/as saline (until cure)</td>
<td>Diarrhea</td>
<td></td>
</tr>
<tr>
<td>Leaf juice with ginger juice</td>
<td>Vomiting</td>
<td>(BEOD, 2017).</td>
</tr>
<tr>
<td>Fruits</td>
<td>Intestinal worms</td>
<td></td>
</tr>
<tr>
<td>Whole plant juice</td>
<td>Sores between the toe fingers</td>
<td></td>
</tr>
<tr>
<td>Root/ rubbed in stone to obtain an extract which is mixed with rice water and the mixture is taken orally twice a day for 4-5 days</td>
<td>Abdominal pain and gastric (acidity)</td>
<td>(Motaleb et al., 2015)</td>
</tr>
<tr>
<td>Fruits/soup prepared with fruits is taken</td>
<td>Hypertension</td>
<td>(Ghorbani et al., 2011)</td>
</tr>
<tr>
<td>Whole plant</td>
<td>Gastrointestinal disorders</td>
<td>(Meyer et al., 2014)</td>
</tr>
</tbody>
</table>

from the plant (Yen et al., 2012).

**Pharmacological activities**

**Anti-oxidant activity**

The methanol and hot water extracts of *S. violaceum* are evident to show anti-oxidant property, where the extracts scavenged 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical and showed reducing power capacity as well as, inhibition of linoleic acid peroxidation (Chiou and Chen, 2009).

**Anti-inflammatory activity**

Isolated compounds from *S. violaceum*, such as indioside G to K, borassoside D, yamogenin 3-O-α-L-rhamnopyranosyl-(1→2)-β-D glucopyranoside, borassoside E, 3-O-chacotriosyl-25(S)-spirost-5-en-3β-ol, sitosterol 3-O-β-D-glucopyranoside, 7-hydroxysitosterol-3-O-β-D-glucopyranoside, *N*-p-coumaroaryltyramine, *trans-N*-feruloyloctopamine and tricalyoside U were evaluated for their anti-inflammatory activity on superoxide anion (O$_2^-$) generation and elastase release induced by FMLP/CB in human neutrophils. Indioside I, borassoside E and 3-O-chacotriosyl-25(S)-spirost-5-en-3β-ol exerted inhibitory effects on O$_2^-$ generation within the half-minimal inhibitory concentration (IC$_{50}$) values 0.62 ± 0.03 to 2.84 ± 0.18 μg/ml. Borassoside E (IC$_{50}$: 111.05 ± 7.37 μg/ml) and 3-O-chacotriosyl-25(S)-spirost-5-en-3β-ol (IC$_{50}$: 4.04 ± 0.11 μg/ml) also inhibited the elastase release (Yen et al., 2012).

**Anti-pyretic activity**

Methanolic extracts of leaf, fruit and root at 250 and 500 mg/kg (p.o.) were also found to reduce the rectal temperature up to a certain period in brewer’s yeast induced hyperpyrexic Swiss mice. However, the leaf extract at 500 mg/kg exerted a similar anti-pyretic effect to that of the 150 mg/kg (p.o.) of paracetamol (standard) (Karim et al., 2017).
Anti-microbial activity

Anti-bacterial activity

In the study of Raju et al. (2013), the whole plant extract at a dose of 400 μg/disc was evaluated for anti-bacterial activity. The zone of inhibitions of plant extracts against Bacillus cereus, Bacillus subtilis, Escherichia coli, Salmonella typhi and Vibrio cholera were 11, 14, 3, 1 and 0 mm respectively. In the study of Rana et al. (2014), the entire plant extract at a dose of 100 μg/disc showed zone of inhibitions of 3.02 ± 0.01 mm, 1.01 ± 0.03 mm, 11.01 ± 0.02 mm and 15.11 ± 0.05 mm as against E. coli, Salmonella spp., B. cereus and S. aureus respectively. However in the study of Jayakumar et al. (2016), the root extract of the plant at a dose of 30 μl/disc exerted zone of inhibitions of 10.2 and 10.1 mm against E. coli and S. aureus, respectively. The minimum inhibitory concentration (MIC) was not determined in any of the studies.

Anti-fungal activity

The zones of inhibitions in disc diffusion method by a dose of 400 μg/disc of the entire plant extracts were found to be 2, 3 and 2 cm against C. albicans, A. niger and M. canis, respectively in the study of Raju et al. (2013). Using poisoned food technique it was observed in the study of Rana et al. (2014) that the whole plant extract caused 50.0 and 45.5% inhibitions of A. niger and C. albicans, respectively. The minimum inhibitory concentration (MIC) was not determined in both of the studies.

Anthelmintic activity

The methanolic extract of the whole plant was found to act against Phertima posthuma, where the extract at 50 mg/ml exerted a mean paralysis time of 31.33 min and a mean death time of 39.67 min. The activity was better than the standard drug albendazole (15 mg/ml) (Raju et al, 2013).

Cytotoxicity

Isolated compounds, such as (22E, 24R)-5α,8α-epidioxyergosta-6,22-dien-3β-ol, (22E,24R)-5α,8α-epidioxyergosta-6,9(11),22-trien-3β-ol, 7-oxostigmasterol, 7-oxositosterol, diosgenin, yamogenin, diosgenone, (25S)-neospirost-4-en-3-one, syringaresinol and scopoletin from the leaves of the plant were evaluated for their cytotoxic potentials against five human cancer cell lines (HepG2 and Hep3B (hepatoma), A549 (lung), and MDA-MB-231 and MCF-7 (breast). (22E, 24R)-5α, 8α-epidioxyergosta-6,22-dien-3β-ol and (22E, 24R)-5α,8α-epidioxyergosta-6,9(11),22-trien-3β-ol exhibited potent cytotoxic effect (IC50 7.73 to 16.74 μg/ml) against all the cancer cell lines (Chang et al, 2013). Moreover, indioside G to K, borassoside E, 3-O-α-L-rhamnopyranosyl-(1→2)-β-D-glucopyranoside, borassoside E, 3-O-chacotriosyl-25(S)-spirost-5-en-3β-ol, sitosterol 3-O-β-D-glucopyranoside, 7-hydroxysitosterol-3-O-β-D-glucopyranoside, N-p-coumaroyltlyramine, trans-N-furuloylctopamine and tricalysiside U were also evaluated for their cytotoxic activity against six human cancer cell lines (HepG2, Hep3B, A549, Ca9-22 (oral), MDA-MB-231 and MCF-7). Indioside H and I, yamogenin 3-O-α-L-rhamnopyranosyl-(1→2)-β-D-glucopyranoside, borassoside E, 3-O-chacotriosyl-25(S)-spirost-5-en-3β-ol exhibited cytotoxic activity against all the cancer cell lines. The IC50 values were found between 1.03 to 8.04 μg/ml (Yen et al., 2012).

Wound healing activity

In a study, the rate of wound contraction, period of epithelialization, skin and granulation tissue breaking strengths, dry granulation tissue weight, hydroxyproline estimation and histopathology of granulation tissue were evaluated using excision, incision and dead space wound models in rats. The aqueous and ethanol whole plant extracts, given both topically and orally, showed a significant wound healing capacity by modulating the aforementioned parameters (Manjunatha, 2006).

Anti-nociceptive activity

Anti-nociceptive activity was evident in hot plate method using Swiss albino mice (Karim et al., 2017). In this study, the methanolic leaf, fruit and root extracts of the plant at 250 and 500 mg/kg (orally administered, p.o.) were found to significantly (p <0.05) increase the latency in a dose-dependent manner when compared to the control groups.

DISCUSSION

Free radicals play important physiological roles in our body. However, excess production is uncontrollable by the body’s antioxidant systems, which can cause oxidative stress (Islam, 2017). Both, reactive oxygen and nitrogen species (ROS/RNS) can damage cellular macromolecules such as carbohydrates, proteins, lipids, and genetic materials (for example, DNA and RNA) (Islam et al., 2017). Undoubtedly, oxidative stress is linked to many pathological conditions in animals. Substances having antioxidant capacity may act by (a) scavenging the ROS/RNS, (b) reducing the oxidized substance to be protected, (c) oxidized and form stable complex, and (d) activate/stimulate/potentiate the physiological
antioxidants. Plants, especially those involved in diets are one of the promising sources of anti-oxidants and can be used in the treatment of many oxidative stress-mediated diseases (Rajput et al., 2017). Some in vitro studies conducted with the *S. violaceum* extracts revealed a potent antioxidant capacity, including scavenging free radicals as well as, inhibition of lipid peroxidation. Moreover, in some toxic substance induced oxidative stress in animal’s organs the plant extract was also found to increase the physiological anti-oxidant systems, suggesting promising anti-oxidant capacity of this plant.

The origins of inflammation are broad. Oxidative stress is also linked to the inflammatory processes by stimulating the production and secretion of pro- and/or inflammatory mediators in a host (Kumar et al., 2017). A small amount of inflammatory response is necessary for physiological functions, including elimination of the initial cause of cell injury, cleared out necrotic cells and tissues damaged from the original insult and the inflammatory process and to initiate tissue repair (Van Eldik et al., 2016).

However, severe, chronic and acute excessive inflammatory reactions are evident to result many disorders and diseases (Quintanilha et al., 2017). The *S. violaceum* derived compounds were found to exert an anti-inflammatory effect in the test system, where an inhibition of O$_2^*$ generation was observed along with the inhibition of elastase release (Yen et al., 2012). Generation of free radicals such as O$_2^*$ (Nesi et al., 2017), release of elastase (Khatib-Massalha et al., 2017) and lipid peroxidation (Yousef et al., 2014) have been evident for inflammatory reactions.

The anti-oxidant and anti-inflammatory effects generally relate to the protective role of a substance. The substances are strong anti-oxidants and are known to exert a pro-oxidative effect in biological systems (Salucci et al., 2017). For example, ascorbic acid is evident to act anti-oxidant (protective) at low dose, while it is cytotoxic at high dose (Putchala et al., 2013). Thus, the cytotoxic effect of *S. violaceum* for its anti-bacterial, anti-fungal and anthelmintic activity may link to its pro-oxidative effects. Finally, the anti-oxidant, anti-inflammatory, wound healing, antimicrobial, cytotoxic, anthelmintic, anti-nociceptive activities of the plant may be linked with each other.

**Conclusion**

*S. violaceum* has been used in traditional medicine to treat a number of diseases and its uses have been scientifically validated through several studies. The plant should be evaluated for its anti-diarrheal and anti-diabetic activities since it is traditionally used in diarrhea and diabetes. Some important molecules have been isolated from the plant parts which were evaluated for their biological activities and many of those possess activities of significance. However, more research is necessary for this promising medicinal plant.

**References**


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