

Phytochemistry and Pharmacological Studies on *Solanum torvum* Swartz

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ABSTRACT

The botany, traditional medicinal uses, phytochemistry, and pharmacology of *S. torvum* Sw. belonging to family Solanaceae have been reviewed by evaluating information on the Internet (using Google Scholar, CAB-Abstracts, Blackwell synergy, Elsevier, Cambridge University Press, JSTOR, Nature Publishing and Science online) and in libraries. Traditional medicinal uses of *S. torvum* were recorded in the Ayurveda and Chinese pharmacopeia. The present review study covered chemical constituents and pharmacological properties of *S. torvum* as well as its morphology. This has included therapeutic effects of the whole plant and its extracts, fractions and isolated compounds. Antimicrobial, anti-ulcerogenic, antiviral, anti-platelet aggregation, antioxidant, analgesic, anti-inflammatory, systolic blood-pressure modification, and cytotoxic activities have all been described. Previous research studies carried out using different in-vitro and in-vivo bioassay techniques supported the claims of the therapeutic utility of the species.

INTRODUCTION

The family Solanaceae represent one of the most economically and medicinally important families of angiosperms. The genus *Solanum* is a hyper-diverse taxon of this family. There are about 2000 species of *Solanum* in the world that are mainly distributed in the tropical and sub-tropical areas, with a small number in the temperate areas (Jennifer *et al.*, 1997). About 21 species and one variety in this genus are used as herbal medicines (Hu *et al.*, 1999). *Solanum torvum* L. is a small solanaceous shrub, distributed widely in Pakistan, India, Malaya, China, Philippines, and tropical America (Nasir, 1985). For many decades, different ethnic groups have used the dried stem and root of this plant for treatment of various ailments. Its Chinese medicinal name is Jinniukou (Anonymous, 2000).

Among the major chemical constituents of *S. torvum* are steroids, steroid saponins, steroid alkaloids, and phenols. Pharmacological studies indicate that the stem and root of *S. torvum* have anti-tumour, anti-bacterial, anti-viral, anti-inflammatory, and other medicinally important effects.

Traditional Medicinal Uses

Solanum torvum is a pharmacologically important species of the family Solanaceae.

Traditional medicinal uses of *S. torvum*, have been highlighted in the Ayurveda and Chinese pharmacopeia. These traditional uses are summarized in the following table (Table 1).

Taxonomical Classification

Kingdom: Plantae; Plants; Subkingdom: Tracheobionta, Vascular plants; Super division: Spermatophyta, Seeds plants; Division: Angiosperma; Class: Dicotyledons; Order: Tubiflorae; Family: Solanaceae; Genus: *Solanum*; Species: *torvum*.

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Table 1: Traditional uses of *Solanum torvum*.

| Traditional uses | Method of utilization | Part used | Community using <i>S. torvum</i> | Reference |
|---|---|--------------------------------|---|-----------|
| Relief from colds and Coughs. | Powder mixed with hot water or cow milk and administered orally | Leaves (after drying in shade) | Puducherry, Karaikal, Mahe and Yanam, India | 39 |
| To cure cracked foot | Externally applied on cracks. Powdered | Root (Extraction) | Kurichyas, Kannur district | 33 |
| Curing coughs | fried fruit is taken for cough | Fruit (after frying) | | |
| To reduce body heat | Leaf juice take orally | Leaf (extractions) | Kancheepuram | 9 |
| Lethal to mice | Aqueous extract of berry | Fruit (extraction) | Mexico | 37 |
| Edible fruit | Cooked fruit as an important ingredient of soups and sauces | Fruit | India | 6 |
| To control bacterial and fungal diseases of <i>S. melongena</i> . | Intercropping cultivation | Whole plant | Indonesia | 13 |
| Asthma, Diabetes, hypertension | Combination of root and leaf juice | Root and leaves | Garo Tribe Bangladesh | 32 |
| Vermifuge. | Cooked fruit | Fruit | Tirunelveli, Tamil Nadu, India | 24 |
| To treat liver diseases, tuberculosis, and as anti-anemic. | Root Juice | Roots | Northeastern Brazile | 4 |

Botany of *Solanum torvum*

Solanum torvum Swartz. Nov. Gen & Sp. Pl. 47.1788; Wight, 1c. Pl. Ind. Or. 2: t. 345; Clarke, 1.c.234; R. R. Stewart, 1c. 645; Shang, *et.al.*, 1.c.329; Nasir, 1.c. 10.

Synonymy

Solanum ficifolium auctt. Non Jacquem.:Roxb., Fl. Ind. (Car.ed) 2, 1: 572. 1832.

Common name

Pea eggplant, cherry eggplant, devil's fig, plate brush, Turkey berry (En). Mèlongène-diable, bellangèrèbàtarde, auberginepois (Fr).

Vernacular names: Sundai

Shrub, 100-300cm tall. Stem and branches are sparsely prickly, stellate tomentose. Stem with stout, reversed, reddish or pale yellow prickles, 0.2-0.1 × 0.2-0.1cm, sometime basal stellate hairs. Leaf petiole 2-4cm long, Leaves solitary or paired, ovate-sinuate, many branched stellate hairs on above surface, lobes rarely deep, never prickly 9-13 cm long, 5-10cm wide, margin sinuate or usually 5-7 lobed, apex acute. Inflorescence extra axillary many flowered racemose panicle cymes, peduncle mostly 1 or 2 branched, short, 0.1-0.4cm long, pubescent.

Flower andromonoecious, pale white, pedicel dark slender, 0.5-0.1cm long, bearing simple glandular and stellate hairs. Sepals 0.2-0.5cm long, lanceolate, sparingly hairy. Corolla glabrous, 0.3-0.5cm long, stellate pubescence abaxially. Filament 0.1cm long, anthers 0.4-0.7cm long. Ovary and style glabrous, 0.6-0.8cm long. Berry yellow, smooth, 1-1.5cm long, calyx lobes present. Seeds, discoid, 0.2cm broad, smooth, yellowish brown in color. (Plate 1)

(Morphological characters of the species studied from the available herbarium specimens of *S. torvum*)

Flowering Period: April-May

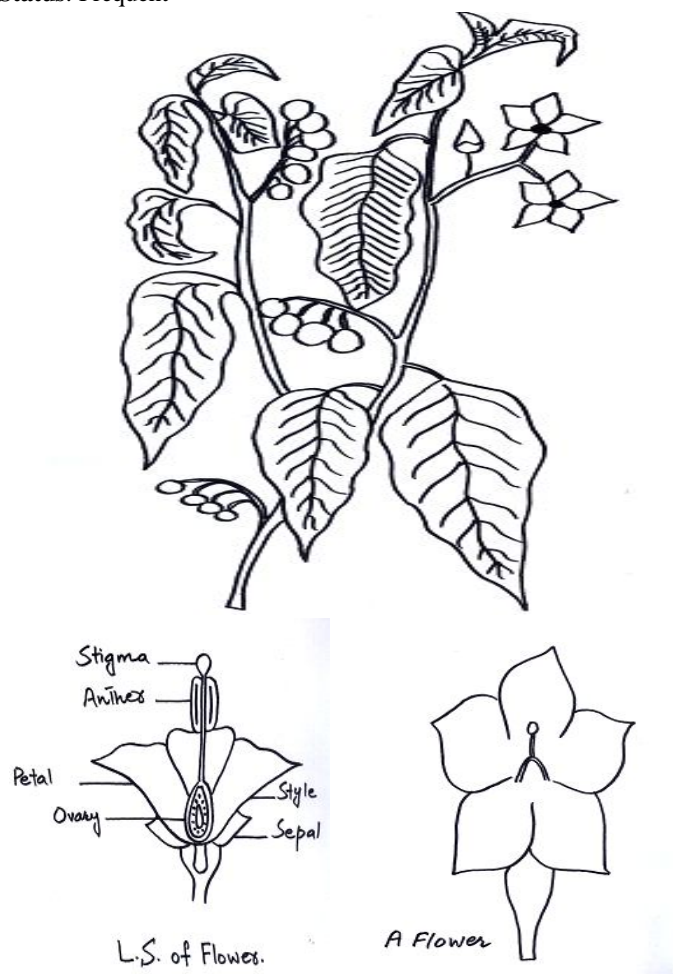
Fruiting Period: it is continuous after the shrubs reach about 1 to 1.5 m

Type: West Indies, Swartz (S).

Distribution

Native to West Indies, India, Myanmar, Thailand, Philippines, Malaysia, China and tropical America. Widely naturalised in South and South East Asia.

Status: Frequent

**Plate. 1:** A branch, L.S of Flower and flower of *Solanum torvum*

Phytochemistry

Solanum torvum has been extensively explored for its chemical constituents. Various parts (fruit, leaves and roots) are being in use for the isolation of a wide range of compounds. This plant species is a very good source of alkaloids, flavonoids, saponins, tannins, and glycosides (Chah *et al.*, 2000). According to Pérez-Amador *et al.* (Perez-Amador *et al.*, 2007), the percentage composition of various compounds within this species is total alkaloid content (0.12%) total glycoalkaloids (0.038%), and glycosylated compounds derived from solasodine, namely solasonine (0.0043%) and solamargine (0.0028%). Kusirisin *et al.* (2009) recorded polyphenolic compounds that included phenol, flavonoids and tannin. The concentrations of these compounds were recorded as 160.30, 104.36 and 65.91 mg/g, respectively.

Compounds isolated from fruit

Antiviral isoflavonoid sulfate and steroidal glycosides were also isolated from the fruits of *S. torvum*. Arthan *et al.*, 2002 investigated MeOH extracts of fruit and found one new isoflavonoid sulfate named as torvanol A, and a new steroidal glycoside, named torvoside H, together with the already-known glycoside, torvoside A.

Compounds isolated from aerial parts:

Aerial parts of *S. torvum* are rich sources of steroid and saponins. Lu *et al.*, 1983 isolated four steroidal compounds solanolide 6-O-[α -l-rhamnopyranosyl-(1 \rightarrow 3)-O- β -d-quinovopyranoside], solanolide 6-O-[β -d-xylopyranosyl-(1 \rightarrow 3)-O- β -d-quinovopyranoside], yamogenin 3-O-[β -d-glucopyranosyl-(1 \rightarrow 6)-O- β -d-glucopyranoside] and solanolide 6-O-[α -l-rhamnopyranosyl-(1 \rightarrow 3)-O- β -d-quinovopyranoside]. Yuan-Yuan *et al.* (2011) reported the isolation of two novel C-22 steroidal lactone saponins, namely solanolactosides A, B (1, 2) and two new spirostanol glycosides, namely torvosides M, N (3,4). Their structures were characterized as solanolide 6-O-[α -L-rhamnopyranosyl-(1 \rightarrow 3)-O- β -D-quinovopyranoside], solanolide 6-O-[β -D-xylopyranosyl-(1 \rightarrow 3)-O- β -D-quinovopyranoside], yamogenin 3-O-[β -D-glucopyranosyl-(1 \rightarrow 6)-O- β -D-glucopyranoside] and neochlorogenin 3-O-[β -D-glucopyranosyl-(1 \rightarrow 6)-O- β -D-glucopyranoside] on the basis of spectroscopic analyses.

Compounds isolated from leaves

Mahmood *et al.*, 1983 isolated torvanol A from the leaves. Yuan-Yuan *et al.*, 2011 were able to isolate nine new compounds namely neochlorogenin 6-O- β -D-quinovopyranoside, neochlorogenin 6-O- β -D-xylopyranosyl-(1 \rightarrow 3)- β -D-quinovopyranoside, neochlorogenin 6-O- α -L-rhamnopyranosyl-(1 \rightarrow 3)- β -D-quinovopyranoside, solagenin 6-O- β -D-quinovopyranoside, solagenin 6-O- α -L-rhamnopyranosyl-(1 \rightarrow 3)- β -D-quinovopyranoside, isoquercetin, rutin, kaempferol and quercetin. Furostanol glycoside 26-O-beta-glucosidase is an important part of methanolic extracts of the leaves. Mahmood *et al.*, 1983 isolated

some non-alkaloidal compounds namely, 3, 4-trimethyl triacontane, octacosanyltriacontanoate and 5-hexatriacontanone by spectral data and chemical studies. Triacontanol, 3-tritriacontanone, tetratriacontanoic acid, sitosterol, stigmasterol and campesterol have also been isolated and identified.

Compounds isolated from roots

The root of *Solanum torvum* is source of steroidal glycosides such as torvosides A-G. They were structurally characterized as (25S)-26-O-(fl- β -glucopyranosyl)-5c-furostan-3fl, 6a, 22sc, 26-tetraol 6-O-[α -L-rhamnopyranosyl-(1 \rightarrow 3)-fl-D-quinovopyranoside], (25S)-26-O-(fl-D-glucopyranosyl)-22c-methoxy-Sa-furostan-3fl, 6ce, 26-triol 6-O-[fl-D-xylopyranosyl-(1 \rightarrow 3)-/3-D-quinovopyranoside], neosolaspigenin 6-O-[α -L-rhamnopyranosyl-(1 \rightarrow 3)-fl-D-quinovopyranoside], neosolaspigenin 6-O-[fl-D-xylopyranosyl-(1 \rightarrow 3)-/3-D-quinovopyranoside], (25S)-26-O-(fl-D-glucopyranosyl)-6a, 26-dihydroxy-22a-methoxy-Sa-furostan-3-one 6-O-(fl-D-quinovopyranoside), (25S)-26-O-(fl-D-glucopyranosyl)-6a, 26-dihydroxy-22a-methoxy-Sa-furostan-3-one 6-O-[/3-D-xylopyranosyl-(1 \rightarrow 3)-/3-D-quinovopyranoside], and (25S)-26-hydroxy-22a-methoxy-5a-furostan-3-one 26-O-(fl-D-glucopyranoside). The structures of various compounds isolated from *S. torvum* are illustrated in Fig. 1.

Pharmacological Properties

Solanum torvum has both a sedative and a diuretic therapeutic effect. The leaves are used as a haemostatic. Phytochemical studies indicated that fruits of this species have good concentrations of various alkaloids, flavonoids, saponins, tannins, and glycosides as sufficient to have pharmacological effects. Therefore, fruit are not only used for nutritive purposes but also fruit decoctions are effective for cough ailments and are considered to be effective medicine in cases of liver and spleen enlargement (Kala, 2005). The ripened fruits are used in the preparation of tonic and haemopoietic agents and also for the treatment for pain (Kala, 2005).

The methanolic extracts of fruits and leaves were reported to have antimicrobial activities against human and animal clinical isolates (Chah *et al.*, 2000). An antiviral isoflavonoid sulfate and various steroidal glycosides were also isolated from fruits (Arthan *et al.*, 2002). However, *S. torvum* exhibited some antioxidant activity and DNA-repair capability in oxidative DNA damage caused by free radicals (Abas *et al.*, 2006). Recently, a novel protein was isolated from water extracts of seed that has been proved to be an effective antioxidant. Sivapriya and Srinivas (Sivapriya *et al.*, 2007) concluded that these proteins are effective even at low doses when compared to well-known standard synthetic antioxidants. Aqueous extracts from the various parts of *S. torvum* exhibit potential anti-inflammatory and analgesic properties (Ndebia *et al.*, 2007).

This herb is commonly used in China and considered effective in the treatment of blood stasis, menstruation, edema pain and coughs.

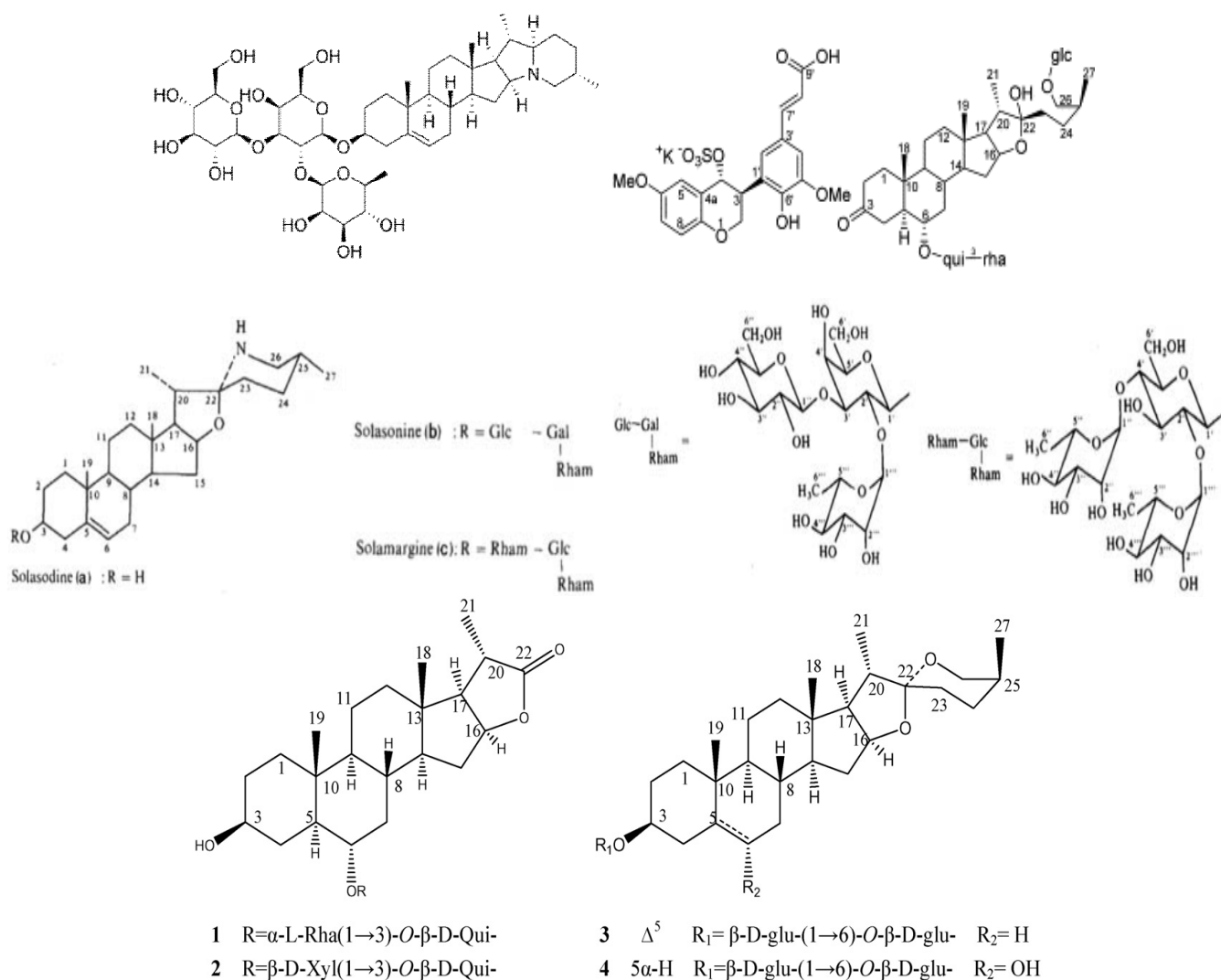


Fig. 1: Compounds isolated from *Solanum torvum*.

Antimicrobial activity

Methanolic extracts of sun-dried fruit of *S. torvum* were found to have effective antimicrobial activity against human and animal clinical isolates. Biochemical analyses of methanolic extracts indicate the presence of alkaloids, flavonoids, saponins, tannins, and glycosides. Chahet *et al.*, in 2000 used methanolic extracts against bacteria (*Actinomyce spyogenes*, *Bacillus subtilis*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, *Staphylococcus aureus*, *Streptococcus pyogenes*) fungi (*Aspergillus niger*, *Candida albicans*) isolated from the clinical samples of humans and animals to evaluate antimicrobial activity by the disc diffusion method. The study concluded that methanolic extracts have significant growth-inhibiting activity against bacteria commonly associated with pyogenic infections (Fig 2). The minimum concentration that inhibits bacterial and fungal activity was 0.3125mg/ml and 1.25mg/ml respectively. However, growth of *Bacillus cereus*, *Bacillus subtilis*, *Candida albicans*, *Escherichia*

coli, *Pseudomonas aeruginosa* and *Staphylococcus aureus* was monitored in the presence of methanolic leaf extracts of *S. torvum* by Wiart *et al.*, in 2004 ; *S. torvum* leaf extracts showed the highest activity against *B. cereus*. Methanolic extracts from fruit and leaves have been described as potentially good sources of antimicrobial agents (David *et al.*, 1998).

These in-vitro studies collectively support the ethnobotanical use of *S. torvum*. Nevertheless, methanolic extracts from the various parts (leaves root and stem) were investigated in the *Biomphalaria glabrata* assay (Tania *et al.*, 2007). It was discovered *S. torvum* extracts are active in brine shrimp bioassay but were inactive against the mollusk *Biomphalaria glabrata* leading to the conclusion that those chemical compounds responsible for the inhibition of microbial activities are present in methanolic extracts of leaves and fruit rather in the whole-plant extracts (Fig 2).

Therefore, leaf and fruit methanolic extraction can be further utilized for the identification of the active compounds.

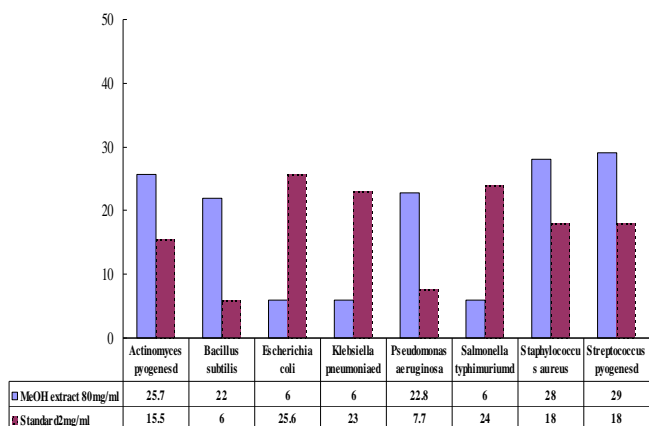


Fig. 2: Antibacterial activity of the methanolic extract of *Solanum torvum* fruit. Minimum inhibitor concentration of MeOH extract is 0.3125 mg/ml.

Minimum inhibitor concentration of MeOH extract is 0.3125 mg/ml.

Anti-ulcerogenic activity

Ulcers are basically discontinuities of the skin or break in the skin, or can be on inner layers of the skin that stops it from continuing its normal protective functions. This breakdown of the skin can occur at any place in the body leading to various types of ulcer including peptic, corneal, venous and genital ulcers. *S. torvum* is reported to have anti-ulcerogenic activity. Nguielefack *et al.*, (2008) investigated anti-ulcerogenic properties of aqueous and methanolic extracts from leaves of *S. torvum* in rats. They induced gastric ulceration by HCl/ethanol, indomethacin, pylorus ligation, and stress. Various doses of aqueous and methanolic extracts at the rate of 250, 500 and 750 mg/kg were tested. Methanolic extracts were fractionated into seven different fractions (A–G) through silica gel column chromatography. These fractions were tested orally at the dose of 100 mg/kg against HCl/ethanol-induced ulceration. Methanolic extracts at the dose of 750 mg/kg produced 98.12, 99.16, 98.70 and 96.03% inhibition when gastric ulcerations were induced by HCl/ethanol, indomethacin, pylorus ligation and stress, respectively (Table 2). Aqueous extracts at the same dose produced 96.55, 96.86, 98.63 and 98.63% inhibition on ulcerations induced respectively by HCl/ethanol, indomethacin, pylorus ligation and stress. All the fractions of the methanolic extracts significantly inhibited ulcer formation. Fractions that contained flavonoids and triterpenes were the most active and exhibited an inhibitory percentage of 84.74 (Table 2). From these results it was obvious that aqueous and methanolic extractions promote production of mucus and reduced gastric-acid secretion. Therefore, although it has effective control of gastric ulceration, *S. torvum* extracts need to be explored for their effectiveness against peptic, corneal, venous and genital ulcers.

Antiviral activity

Herpes simplex virus (HSV) is responsible for human infections in the orofacial region (HSV-1) and in the genital region (HSV-2) (Travis, 2002). Type 1 (HSV-1) of Herpes simplex virus was tested against methanolic fruit extracts of *S. torvum*. HSV-1 was maintained in the Vero cell line (kidney fibroblast of an

African green monkey), which was cultured in Eagle's minimum essential medium (MEM) with addition of heat-inactivated fetal bovine serum (FBS) (10%) and antibiotics. The test samples were put into wells of a microtiter plate at final concentrations ranging from 20 to 50 mg/ml. The viral HSV-1 (30 PFU) was added into the 96-well plate, followed by plating of Vero cells (1105 cells/ml); the final volume was 200 ml. After incubation at 37 °C for 72 h, under 5% CO₂ atmosphere, cells were fixed and stained, and optical density measured at 510 nm. Under these screening conditions, the reference compound, Acyclovir, typically exhibited an IC₅₀ of 2-5 mg/ml for HSV-1. Torvanol A, torvoside H, and solasonine also inhibited the expression of herpes simplex virus-1 (HSV-1), and the activity may relate to the entering of glycosides into the viral capsules (Arthan *et al.*, 2002).

Effect on Systolic Blood Pressure

High blood pressure is generally considered to be induced by a diet rich in fructose. Ethanolic extracts of *S. torvum* act by preventing and reversing the development of hyperinsulinemia to control the rise in systolic blood pressure (Mohan *et al.*, 2009). The Mohan group investigated the effect of *S. torvum* on blood pressure and metabolic alterations in the fructose hypertension condition generated in rats. The hypertensive conditions were induced in male Wistar rats (150–200 g) by a high-fructose diet (fructose 10%, w/v) *ad libitum* for six weeks. For measurements of systolic blood pressure, non-invasive (indirect) and invasive (direct) methods were used. Ethanolic extractions of *S. torvum* were demonstrated to be effective in preventing high systolic blood pressure (Fig 3).

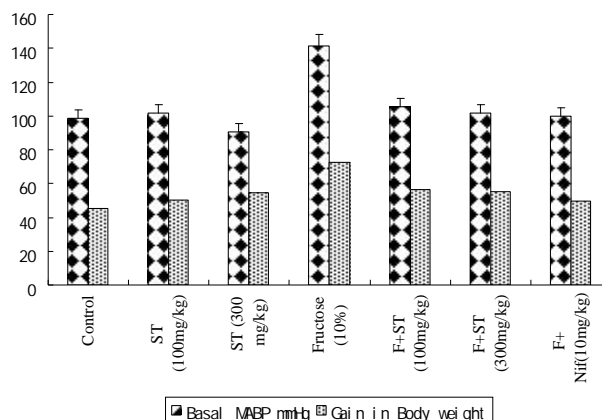


Fig. 3: Effect of *Solanum torvum* (100 mg/kg and 300 mg/kg, p.o., for 6 weeks) on mean arterial blood pressure and change in body weight in fructose (10%) induced hypertensive rats.

Nguielefack, *et al.*, (2008 & 2009) also supported the findings of Mohan *et al.*, (2009). They orally administered aqueous extracts of *S. torvum* fruit (AEST) to investigate effectively of AEST in hypertensive conditions. Rats were given AEST (200 mg/kg/day, p.o.) solely or concomitantly with 1-NAME (40 mg/kg/day, p.o.) for 30 consecutive days. It was found that AEST induced neither mortality nor visible signs of toxicity. When given solely or in co-administration with. However 1-

NAME put the rats in hypertensive conditions. Whereas AEST increased the sensitivity to noradrenalin. In normotensive and significantly reduced it in hypertensive animals. AEST significantly increased urinary volume and sodium excretion in 1-NAME treated animals while reducing the sodium excretion in normotensive to reduce hypertensive conditions.

Anti-platelet aggregation activity

Haemostatic properties of *S. torvum* impart to it an anti-platelet aggregation effect (Henty, 1973). The anti-platelet aggregation activity of aqueous extracts of *S. torvum* (AES) was evaluated *in vitro* on platelet aggregation initiated by thrombin and ADP (Nguelefacka *et al.*, 2008). Results showed that anti-platelet aggregation activity is concentration dependent. At 2 mg/ml, AES reduced the amplitude of the aggregation signal induced by thrombin from 9.27 cm to 4.03 cm, representing an inhibition of 55.27%. This effect was significantly higher than that of the lower concentrations 0.5 and 1 mg/ml. Similarly, AES also exerted significant concentration-dependent inhibitory effects on aggregation triggered by ADP. The effect in terms of inhibitory percentage was 31.63%, 47.07% and 56.40% at concentrations of 0.5, 1 and 2 mg/ml respectively.

Anti-oxidant activity

Phenolic compounds extracted from different parts of *S. torvum* exhibited anti-oxidant activity (Loganayaki *et al.*, 2010). Chloroform, acetone, and methanol extracts of leaves and fruit were explored for their *in-vitro* antioxidant activity using ferric reducing antioxidant power, 2,2'-diphenyl-1-picryl-hydrazyl (DPPH), ABTS^{•+}, iron chelation, and anti-hemolytic activity. Significantly higher concentrations of phenol were recorded for chloroform extracts (Table 3). Of note was the fact that the *in-vitro* antioxidant activity was shown to be highly dependent on total phenolic content ($p < 0.01$). The DPPH and 2, 2' azinobis (3-ethyl benzothiazoline -6- sulfonic acid) diammonium salt (ABTS) cation radical scavenging activities were well proved with the ferric reducing antioxidant capacity of the extracts. However, peroxide clearing studies indicated that aqueous extracts of *S. torvum* fruit had anti-oxidant activities (Re *et al.*, 1999). This species also exhibited some percentage of antioxidant activity and DNA-repair capability on oxidative DNA damage caused by free radicals (Abas *et al.*, 2006).

Cytotoxic effect

Among the chemical constituents of *S. torvum*, steroidal lactone saponins and spirostanol glycosides are important for cytotoxicity. Lu *et al.* (2009) isolated new steroidal lactone saponins and spirostanol glycosides from ethanolic extracts of aerial parts. All the four compounds (Solanolactoside A, Solanolactoside B, Trovoside M and Trovoside N) were evaluated for cytotoxic effects *in vitro* against a panel of human cancer cell lines: MGC-803 (Human gastric cancer cell line), HepG2 (Human hepatocellular liver carcinoma cell line), A549 (human lung adenocarcinoma cell line) and MCF-7 (Human breast

adenocarcinoma cell line). Cis-diamminedichloroplatinum (CDDP, Sigma) was used as a positive control. The dose concentration was maintained at 5mg/ml. The effects of two compounds (Solanolactoside A, Solanolactoside B) were not significant; however, the other two compounds Trovoside M and Trovoside N had significant cytotoxicity (Fig.4).

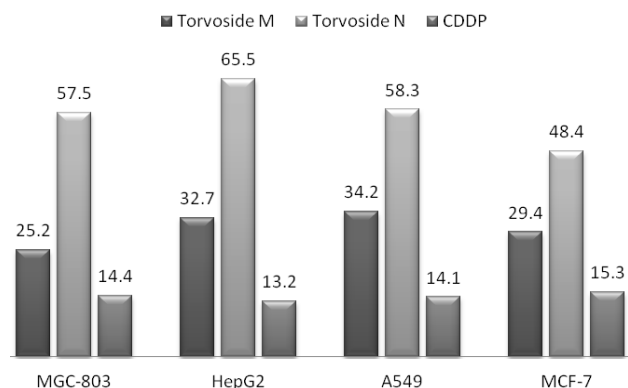


Fig. 4: Cytotoxicity of saponins extracted from ethanol extract of aerial parts of *Solanum torvum*.

Analgesic and Anti-inflammatory Effects

S. torvum is amongst the important medicinal species used as analgesic and anti-inflammatory agents in different traditional medicinal systems (Ndebia *et al.*, 2007). The analgesic and anti-inflammatory activity of *S. torvum* was evaluated for chemical and mechanical stimuli. Abdominal writhing and paw edema were induced in rats by using 1% acetic acid (1 ml/100 g body weight) and 0.05 ml of a solution of 1% sterile carrageenan in saline, respectively. For the treatment of 1% acetic acid (1 ml/100 g body weight) induced abdominal writhing, aqueous extracts of *S. torvum* were utilized along with three other painkillers. The aqueous leaf extracts of *S. torvum* significantly inhibited the pain (Fig.5). Paw edema induced by the 0.05 ml of a solution of 1% sterile carrageenan was treated by indomethacin (10mg/kg), *S. torvum* (300mg/kg) and *S. torvum* (600mg/kg). Extracts of *S. torvum* (300mg/kg) and *S. torvum* (600mg/kg) significantly inhibited the paw edema although the lower dose 300mg/kg worked more effectively in a shorter time period compared with the high dose of 600mg/kg (Table 4).

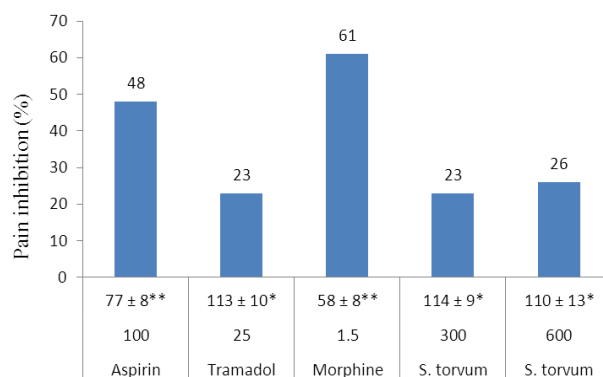


Fig. 5: Effect of the aqueous leaf extracts of *S. torvum* on acetic acid-induced pain.

Table. 2: Effect of *Solanum torvum* extracts on gastric lesions induced by four methods.

| S. No | Mode for induction of ulcer | Methanolic Extracts | | Aqueous Extract | |
|-------|-----------------------------|---------------------|-----------------------|-----------------|-----------------------|
| | | Conc. mg/kg | Inhibition percentage | Conc. mg/kg | Inhibition percentage |
| 1 | Pylorus ligation | 250 | 47.62 | 250 | 50.56 |
| 2 | | 500 | 78.75 | 500 | 78.62 |
| 3 | | 750 | 98.70 | 750 | 98.63 |
| | indomethacin | 250 | 44.60 | 250 | 41.83 |
| | | 500 | 80.33 | 500 | 77.82 |
| | | 750 | 99.16 | 750 | 96.86 |
| | HCl/ethanol | 250 | 41.22 | 250 | 36.87 |
| | | 500 | 79.68 | 500 | 78.39 |
| | | 750 | 98.12 | 750 | 96.55 |
| | Cold-restraint stress | 250 | 33.51 | 250 | 38.97 |
| | | 500 | 73.20 | 500 | 73.61 |
| | | 750 | 96.03 | 750 | 95.81 |

Note: Values with bold font are highly significant for the control of gastric ulcers.

Table. 3: Extract yield, total phenolic content in various solvent extracts from *S. torvum* and DPPH, antihemolytic and FRAP activities.

| Samples | Extract Yield (%) | Total Phenolics (g TAF/100g extract) | DPPH radical scavenging activity 1C ₅₀ DPPH (µg) | Antihemolytic activity (%) | Ferric-reducing/antioxidant power assay (FRAP) |
|---|-------------------|--------------------------------------|---|----------------------------|--|
| <i>S. torvum</i> leaf Chloroform extract | 34.4 | 2.90.1 | 30 | 71.2 | 537±40.8 |
| <i>S. torvum</i> leaf Methanol extract | 7.8 | 2.10.1 | 55 | 54.9 | 46.5±02.9 |
| <i>S. torvum</i> leaf Acetone extract | 4.1 | 1.30.1 | 40 | 56.3 | 143.9±13.2 |
| <i>S. torvum</i> fruit Chloroform extract | 68.2 | 8.50.4 | 28 | 92.6 | 552.8±28.1 |
| <i>S. torvum</i> fruit Methanol extract | 3.8 | 0.80.0 | 50 | 58.4 | 427.3±69.3 |
| <i>S. torvum</i> fruit Acetone extract | 2 | 0.40.0 | 58 | 58.9 | 206.1±16.8 |

Table. 4: Anti-inflammatory activities of aqueous extracts of *S. torvum* in carrageenan-induced hind paw edema (in terms of % inhibition).

| Treatments | Dose (mg/kg) | % inhibition | | | |
|------------------|--------------|--------------|------|------|------|
| | | 1H | 2H | 3H | 4H |
| Indomethacin | 10 | 43 | 62** | 82** | 85** |
| <i>S. torvum</i> | 300 | 34 | 31 | 39** | 47** |
| <i>S. torvum</i> | 600 | 11 | 4 | 41 | 49** |

Effects on smooth muscles

Solasonine inhibited cat isolated heart contraction and contraction of the isolated guinea pig ileum and cat trachea induced by acetylcholine. It also had a contracting effect on isolated rabbit aural blood vessels, and could induce contraction and spontaneous activities of isolated rat uterus (Basu&Lahiri, 1997).

CONCLUSIONS

Solanum torvum is a pharmaceutically important member of the potato family. The species is included among the ingredients of various indigenous herbal medicines for treating a number of diseases. Moreover, anticancer phenolic compounds have also been isolated from fruit and leaves of this plant. The presence of various potentially important compounds justifies exploration of its medicinal qualities reinforced by its importance in indigenous herbal and conventional medicines. In addition, there is a need to explore the local indigenous uses of this plant in different communities. This review reveals that the photochemistry of *S. torvum* will remain an important topic of pharmaceutical research. It has been extensively explored for compounds such as alkaloids, phenols, and steroidal saponins. Is flavonoid sulfate and steroidal glycosides are important antiviral compounds and they have been isolated from the fruit. To date, steroidal glycosides (22, 3, 10, 1; 12), and long-chain hydrocarbons and steroids

(Mahmoud *et al.*, 1983) have been isolated and have evaluated for their therapeutic effect. Literature searches on *S. torvum* revealed that research on its biodiversity, conservation; genetic diversity, phylogeny, nucleotide sequence, chemotaxonomic variation, and allelopathy have yet to be conducted. These areas of research should be explored in the future.

Recommendations

Short-term goals

- 1-Genetic diversity within and among populations of *S. torvum* must be evaluated.
- 2-Chemotaxonomic studies must also be conducted to determine chemotypical variations in populations of *S. torvum*. Genus and family specific alkaloids, steroidal saponins, phenols etc. of *S. torvum* must be identified and used as a taxonomic tool in chemotaxonomy.
- 3-As *S. torvum* is always collected from the wild resources, there might be reduction in the population of this species. The only way to reduce the pressure on natural resources is to bring medicinally important plant species into cultivation. Therefore, it is important to explore the relationships of *S. Torvum* with other species growing in its close vicinity. Allelopathic studies of *S. torvum* should also be conducted. On the basis of its richness in various chemical compounds, this species may also possess allelochemicals. Therefore, studies on the identification and isolation of dominant allelochemicals of *S. torvum* are required

Long-term goals

The safety and efficacy of herbal drugs and their ingredients used for the treatment of various diseases must be thoroughly investigated and monitored independently.

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