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Phytochemical Profile and Antioxidant Potential of *Solanum torvum* Swartz: An Integrated Review

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ABSTRACT

Solanum torvum Swartz, also known as turkey berry, is a medicinal herb in the Solanaceae family traditionally used to treat infections, hypertension, and liver diseases. Due to increasing concerns about the safety of synthetic antioxidants, interest in plant-based alternatives has grown, and this turkey berry has garnered attention due to its impressive phytochemistry and strong antioxidant properties. This review covers the plant's taxonomy, modern ethnomedicine, phytochemical profile, and antioxidant activity, based on existing literature. All parts of turkey berry (leaves, fruit, roots, and seeds) have been examined for antioxidant activity through extraction methods and various assays, including DPPH, FRAP, ABTS, hydrogen peroxide, nitric oxide, lipid peroxidation, and total antioxidant capacity. The plant contains several phytochemicals, such as alkaloids, flavonoids, phenolics, steroidal glycosides, saponins, and vitamins. It has long been used in traditional medicine to treat a range of health conditions, including ulcers, hypertension, diabetes, and cancer, and is known for its neuroprotective, immunomodulatory, hepatoprotective, antioxidant, and antimicrobial effects. This review consolidates findings from 22 studies on S. torvum, all highlighting its significant antioxidant activity. In conclusion, turkey berry shows great potential as a natural source of antioxidants, aligning with its traditional medicinal uses. Further research should focus on isolating and characterizing phenolic and flavonoid compounds and validating these findings through clinical studies.

Introduction

Many studies have mainly focused on the link between oxidative stress and the development and progression of both chronic and acute diseases [1, 2]. Several antioxidant food additives are being removed from the market due to their adverse effects. Different fruits and plant-based materials are being suggested for their beneficial properties and offer promising natural alternatives to synthetic food additives [3]. Plants are a source of unique and diverse antioxidants, including alkaloids, flavonoids, carotenoids, polyphenols, and vitamins [4]. Medicinal plants are commonly used as dietary sources, are associated with fewer side effects, and exhibit antioxidant and free radical scavenging properties, such as *S. torvum*. For instance, *S. torvum* has demonstrated a certain level of antioxidant activity and the ability to repair DNA damage caused by free radicals [5]. More recently, a newly identified protein extracted from the water-based seed extract of *S. torvum* showed strong antioxidant activity, proving effective even at low doses when compared to conventional synthetic antioxidants [6]. Nonetheless, considerable interest still exists in S. torvum, especially for its aqueous extract, which has shown anti-inflammatory and analgesic effects [7].

Solanum torvum Swartz is a small-sized shrub belonging to the Solanaceae family, has an average height of 5 m, and is characterized as having a taproot root system. Its distribution is present in the tropics of Africa, Asia, and the West Indies, where it is grown and consumed. It is prevalent across Malaysia, China, the Philippines, Thailand, and the West Indies and Tropical America [8].

As an erect shrub (1–3 m height) with a pricky stem. The plant features a thorny stem, with its green stems and branches covered in trichotomous hairs. As the stems mature, the bark turns brown to dark grey. Young stems and branches retain a bright green colour, while the leaves, which remain green year-round, are broadly ovate in shape, measuring approximately 5–21 cm in length and 4–13 cm in width. The leaf margins are generally entire, though they may occasionally exhibit up to seven broad, triangular lobes [9].

Pharmacological studies show that extracts of this plant exert a wide range of biological activities, such as antiviral, immunosecretory (promoting immune secretion), and antioxidant, analgesic, anti–inflammatory, and anti–ulcer [10-15]. A variety of compounds have been isolated from *S. torvum* leaves and including these steroidal glycosides, known as torvosides A–M, and β-sitosterol glucopyranoside.

Based on a study of the leaves, one could name 7 compounds, torvosides A–G, all accessed from the roots of the plant [10, 16-21]. In the fruit the plant contains, large amounts the novel bioactive compounds, including the triacontane derivatives, chlorogenone and neochlorogenone, one sulfated isoflavonoid, and the steroidal glycosides such as 22-β-O-spirostanol oligoglycosides, and one 26-O-β-glucosidase enzyme, just to name a few. These compounds and enzymes may be responsible for the range of pharmacological effects of this species [16]. Traditional uses of the *S. torvum* include such as liver treatment, spleen enlargement, antimicrobial property, sedative, diuretic, cough, and anti-tussive properties [22]. The current study was carried out to gain deeper insight into the medicinal potential of the plant by thoroughly analyzing the *in-vitro* antioxidant activity of *S. torvum*.

Fig 1. Parts of *S. torvum* plant

Taxonomic classification

Botanical name: *Solanum torvum*

Family: Solanaceae (nightshade family)

Kingdom: Plantae

Division: Tracheophyta

Sub-division: Angiospermae

Class: Magnoliopsida (Dicotyledons)

Order: Solanales

Genus: *Solanum*

Species: *Solanum torvum* Swartz

Vernacular names

Tamil: Sundaikai

English: Turkey berry

Telugu: Uathikaya

Kannada: Bhenda hannu

Malayalam: Chundakka

Hindi: Bhurat

Marathi: Bhui ringani

Bengali: Tit baegun

Gujarati: Bhoringani

Sri Lanka: Thibbatu

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First introduced in Caledonia around 1900, where it became invasive in pasture lands. It is believed to be indigenous to tropical regions spanning Mexico, Central America, the Caribbean, and parts of South America. Its adaptability helped it naturalize rapidly; it now thrives across Africa, Asia, and Australia, and the Pacific islands, often in distributed habitats. It is widely used in folk medicine and in culinary tradition. In folk medicine, it treats various illnesses like respiratory illness, digestive complaints, skin disorders, Malaria, and Hypertension. Other properties include antimicrobial, anti-ulcerogenic, antiviral, antioxidant, and immunomodulatory effects [23].

Phytochemistry

The whole plant has medicinal value and has therefore been the focus of chemical studies. The starting part of the root contains glycosides, saponins, and alkaloids such as Jurubin and Jurubine, which help treat skin infections and possess other properties including anti-inflammatory and anti-tumor effects. Next, the stem contains alkaloids, tannins, phenols, flavonoids, sterols, and proteins used for antihypertensive and anti-cancer effects [24]. Additionally, the leaf contains constituents like solasonine, solasodine, chlorogenin, 3-Triacotanone, 1-Triacontanol, tetratriacontanoic acid, torvonin-B, torvonin-A, solaspigenin, stigmasterol, campesterol, and beta-sitosterol. The leaf extract is used for treating bacterial infections, as an analgesic, for metabolic balance, antihypertensive [25], antifungal, hepatotoxicity effects [26], and also acts as a mosquito larvicidal agent [27]. Finally, the fruit contains sisalagenone, torvogenin, retinol, spirostane-3,6-dione, and is used for hypolipidemic, hepatoprotective, antidiabetic [28], antioxidant [29], and neuroprotective activities [30].

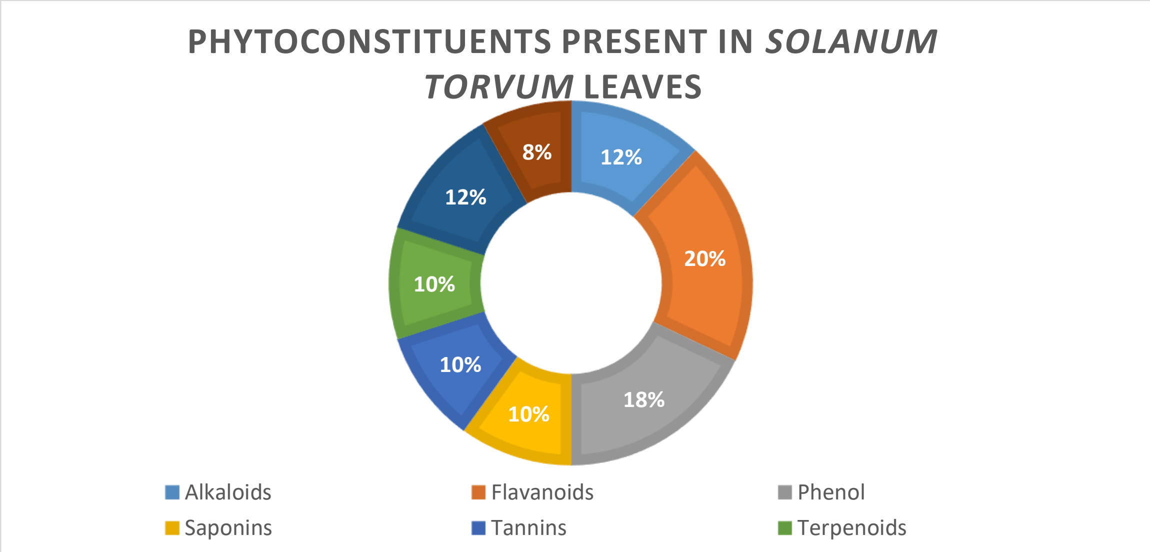

Fig 2. List of phytoconstituents found in *S. torvum* plant

Pharmacological studies

The pharmacological effects of *S. torvum* have been widely studied through in vitro research. This review examines the results of twenty-two studies that specifically highlight its antioxidant potential.

***In-vitro* Antioxidant studies**

The antioxidant activites of the *S. torvum* have been thoroughly investigated in a total 22 studies, by employing various assay such as 2, 2 -Diphenyl-1-picrylhydrazyl (DPPH), Ferric Reducing Antioxidant Power(FRAP), 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), Butylated Hydroxytoluene (BHT), Thiobarbituric Acid Reactive Substance (TBARS) and Hydrogen peroxide assay (H_2O_2), CUPric Reducing Antioxidant Capacity (CUPRAC). Table 1 presents a detailed overview of *in-vitro* studies conducted to evaluate the antioxidant potential of *S. torvum*, highlighting the phytoconstituents involved, types of extracts used, methodologies employed, and corresponding outcomes.

Antioxidant studies carried out on different parts of *S. torvum* Plant

Plant	Author and Year of the study	Parts of the plant	Type of the extract	Method used	Inference of the study	Reference
Solanum torvum	Kusirisin W, et al. (2009)	Fruit	Ethanolic extract by maceration.	- Lipid peroxidation - Superoxide anion scavenging assay	The antioxidant capacity of 1g of the *S. torvum* (ST) extract was equivalent to an antioxidant capacity of 3.68 mg of Trolox and 360.53 mg of ascorbic acid. IC50 - 20.60 µg/mL, when assessing lipid peroxidation, while the superoxide anion ($O2^{-}$) scavenging IC_{50} was determined to be 10.26 µg/mL.	31
	Lee JH, et al. (2010)	Leaf and fruit (Powdered)	Chloroform, methanol, and acetone extract by maceration.	- DPPH - FRAP - Total antioxidant activity.	Among the extracts, the chloroform extracts of the fruits showed the highest extract yield and phenolic concentration. Specifically, the *S. torvum* fruit chloroform extract exhibited the highest DPPH radical scavenging capacity. Additionally, the study revealed a strong positive correlation between total phenolic content and antioxidant activities, showing an R^2 value of 0.8131 for the	32

					relationship between phenolics and anti-hemolytic activity, 0.5256 for phenolics vs. FRAP, and 0.8358 for FRAP vs. total antioxidant activity (TAA).	
	Gandhi GR, et al. (2011)	Fruits (unripe)	Methanolic extraction by maceration	- DPPH assay	*S. torvum* methanol extract (STMe) treatment also improved the activity of carbohydrate-metabolizing enzymes, and antioxidant defense mechanisms were strengthened, as indicated by the normalization of superoxide dismutase, catalase, glutathione peroxidase, and lipid peroxidation markers.	33
	Thenmozhi A, et al. (2012)	Leaf and fruit (Powdered)	Chloroform, ethanol and aqueous extract by boiling.	- DPPH assay	The study demonstrated that *S. torvum* contains a rich profile of phytochemicals and antioxidants such as vitamins A, C, E, polyphenols, sterols, proteins, carbohydrates, and saponins. superoxide radical was detected in this study by the reduction of nitroblue tetrazolium (NBT) to a blue formazan product, with absorbance measured at 560 nm	34

	Waghulde H, et al. (2012)	Fruit	Ethanolic extract and methanolic extract by maceration	- DPPH - Hydrogen peroxide scavenging.	The extract of *S. torvum* showed the strongest antioxidant activity, as indicated by its lowest IC_{50} value in the DPPH assay (180 ppm) and hydrogen peroxide scavenging (130 ppm) assays, strong total antioxidant activity (IC_{50} = 245 ppm), and highest reducing power.	35
	Nithiyananth am S, et al. (2012)	Fruits	Methanolic extraction by maceration	- DPPH - ABTS - FRAP - Phosphormolybde num - lipid peroxidation - Hydroxyl radical scavenging method	Raw *S. torvum* had higher total phenolic (5.8 g/100g) and tannin content (5.3 g/100g) and higher ABTS scavenging activity. This implies that some antioxidant compounds degrade when heated/cooled/processed, but both raw and processed extracts inhibited lipid peroxidation (~98%) equivalent to or better than the standard antioxidants BHA and BHT.	36
	Kannan M, et al.	Leaves	Petroleum ether and methanolic	- Radical scavenging assay	The investigation indicated that *S. torvum* displayed moderate antioxidant activity when using Fenton's reagent	37

	(2012)		extraction by soxhlet extraction		and radical scavenging assays. In both assays at higher concentrations, the antioxidant activity increased compared to an extract concentration at 0.0325%.	
	Xu J, et al. (2012)	Root and shoots	Total RNA was extracted from transcriptomic profiling	- Grafting experiments - Cadmium and iron supply assays - RNA-Seq transcriptome analysis.	*S. torvum* demonstrated markedly elevated levels of reactive oxygen species (ROS), including superoxide anion (O_2^-) and hydrogen peroxide (H_2O_2) through cadmium stress, indicating a weaker free radical scavenging capacity compared to *S. nigrum*.	38
	Waghmare R, et al. (2015)	Fruits	n-hexane extract, ethyl acetate extract and ethanol extract.	- DPPH - ABTS.	Ethanolic extract of S. torvum had the lowest IC_{50} for both DPPH (1.4 µg/mL) and ABTS (2.36 µg/mL), indicating highest antioxidant potential.	39

	Latha P, et al. (2015)	Fruits dried, powdered form	n-hexane, ethanol, chloroform, petroleum ether, methanol and aqueous extract by soxhlet extraction.	- Free radical scavenging method.	The aqueous extract had the strongest free radical scavenging activity against DPPH ($IC_{50} = 287.9$ µg/ml) and nitric oxide ($IC_{50} = 336.97$ µg/ml).	40
	Begam AKU, et al. (2015)	Seed	Standard protein purification method	- Oxidative hemolysis assay - K^+ leakage test - ATPase activity assay - Lipid peroxidation assay.	Purified *S. torvum* seed protein (SP) demonstrated remarkable antioxidant prowess against oxidative stress; up to 86% hemolysis inhibition, nearly complete (95%) inhibition of K^+ leakage, and restoration of key membrane.	41

	Vinothkumar R, et al. (2016)	Fruits	Aqueous, ethanolic and methanolic extract by the cold maceration.	- FRAP - DPPH	In the DPPH radical scavenging assay, the IC_{50} value was recorded at 1.62 mg/mL, whereas in the FRAP assay, the ethanolic extract of the fruit showed a FRAP value of 470 mg $FeSO_4$ equivalents per gram.	42
	Pratheepa V, et al. (2016)	Fruit, Leaf and Stem	Methanolic extract by maceration.	- FRAP - DPPH	The stem contained the highest total phenolic content at 43.92 mg GAE/g, while the leaf had the greatest total flavonoid content at 40.6 mg QAE/g. Although the leaf extract exhibited the strongest DPPH radical scavenging activity at 78.7%, the stem extract demonstrated the highest ferric-reducing antioxidant capacity, measured at 540 mM Fe^{2+}/g.	43
	Prasad M, et al. (2016)	Fruits	Ethanolic, ethyl acetate, n-hexane extract	- FRAP - CUPRAC - H_2O_2 scavenging	The ethanolic and ethyl acetate fruit extracts of turkey berry demonstrated the highest antioxidant capacity based on - FRAP (EC_{50}: 41.32 µg/mL)	44

			by reflux condenser.	- Phosphomolybdenum assay - Betacarotene bleaching (BCB).	- Hydrogen peroxide scavenging assay (IC_{50}: 1.01 µg/mL) - CUPRAC assays (EC_{50}: 117.56 µg/mL). In contrast, the ethyl acetate fruit extract of round green eggplant had the strongest activity - Phosphomolybdenum capacity (EC_{50}: 375.47 µg/mL) - BCB capacity (EC_{50}:158.66 µg/ml)	
	Kumar RSAS, et al. (2016)	Seeds, leaves, and mature fruits	Methanolic extract of leaf, aqueous extract of leaf, methanolic extract of fruits, aqueous extract of fruits.	- DPPH - Hydroxy free radical scavenging assay.	Among the extracts tested, the aqueous extract of *S. torvum* fruit exhibited the highest antioxidant activity, achieving 33.72% inhibition of hydroxyl radicals.	45

	Ahmed T, et al. (2018)	Leaves and fruits	Methanolic extract	- DPPH assay	The IC_{50} values for DPPH radical scavenging ranged from 31.52 mg/mL.	46
	Djoueudam FG, et al. (2018)	Dried leaves	Hydro ethanolic extract, Ethanolic extract and aqueous extract	- DPPH - FRAP - Nitric oxide scavenging method - Hydroxyl radical scavenging method.	The lowest IC_{50} in the - DPPH assay (13.62 µg/mL) - Nitric oxide scavenging (62.43%) - Hydroxyl radical scavenging (49.97%) - Ferric reducing power assessed in terms of absorbance (2.12 at 200 µg/mL)	47

	Afolabi OO, et al. (2019)	Seeds	Methanol extract, ethyl acetate extract, and chloroform,	- FRAP - DPPH - BTS - Superoxide anion scavenging method - Hydrogen peroxide radical - Hydroxyl radical - Nitric oxide radical scavenging assay.	*S. torvum* seed of ethyl acetate extract displayed the strongest antioxidant activity when examined via the different assays. - DPPH assay: 52.61% scavenging at 400 µg/mL (BHT = 56.09%). - ABTS assay: 52.61% at 400 µg/mL - FRAP assay: 52.80% at 400 µg/mL - Nitric oxide scavenging: 41.74%. - Superoxide radical inhibition: 39.49% - Hydroxyl radical inhibition: 43.73% - Hydrogen peroxide scavenging: 40.41%	48
	Sani S, et al. (2022)	Leaves	Ethanolic extraction by percolation.	- DPPH - FRAP	The ethanolic extract of *Solanum torvum* leaves (EESTL) exhibited dose-dependent DPPH radical scavenging activity, with an IC_{50} value of 13.52 ± 0.45 µg/mL. EESTL also demonstrated notable antioxidant effects in both	49

				- Lipid peroxidation assay.	TBARS and FRAP assays. The antioxidant activity increased progressively at concentrations of 15.63 and 31.25 µg/mL.	
	Ofori Attah E, et al. (2023)	Fruits	Aqueous extract	- DPPH assay - Nitric oxide assay.	The EC_{50} value for DPPH free radical scavenging activity indicated that *Solanum torvum* possessed the strongest antioxidant potential, with an EC_{50} of 0.466 ± 0.09 mg/mL.	50
	Tesfaye S, et al. (2024)	Fruits and leaves	Freeze dried method, ethanolic and aqueous extraction.	- DPPH assay	Among the aqueous extracts, the fruit extract of *S. torvum* demonstrated the highest antioxidant activity (61.34 ± 1.05 mg/mL), followed by the leaf extract. The aqueous leaf extract contained the highest total phenolic content, measured in mg of gallic acid equivalents (GAE) per gram of dry plant material. Meanwhile, the ethanolic fruit extract had the highest overall phenolic content, reported as 15.88 ± 0.87 mg/g GAE.	51

	Efianti NWM, et al. (2025)	Leaves	Ethanolic extract by maceration	- DPPH assay - Antioxidant Activity Index	Antioxidant tests showed that the 70% ethanol extract of the *Solanum torvum* leaves possessed strong activity (IC_{50} = 49.9 ppm), signifying very high ability and the 96% ethanol extract had moderate activity (IC_{50} = 65.7 ppm). The Antioxidant Activity Index (AAI) was also higher for the 70% ethanol extract (0.80) than for the 96% ethanol extract (0.60).	52

Abbreviations: DPPH- 2,2 -Diphenyl-1-picrylhydrazyl; FRAP- Ferric Reducing Antioxidant Power; ABTS- 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid); BHT- Butylated Hydroxytoluene; TBARS- Thiobarbituric Acid Reactive Substance; CUPRAC- CUPric Reducing Antioxidant Capacity; GAE- Gallic Acid Equivalents; QAE- Quercetin Equivalent.

[TABLE NO. 1]

Discussion

Oxidative stress has been accepted as an integral part of the pathogenesis of chronic or acute human diseases such as cancer, diabetes mellitus, cardiovascular disease, and neurodegeneration. While the use of synthetic "antioxidants" is being re-evaluated due to toxicity and lack of stability, *S. torvum* appears to provide a wide range of plant-based bioactive antioxidants and pharmacological possibilities. The current literature extensively documents the phytochemical richness of *S. torvum* leaves, fruits, roots, and seeds, which contain a diverse range of bioactive phytochemicals (e.g., alkaloids solasodine, solasonine; flavonoids, e.g., quercetin, rutin; phenolics, e.g., chlorogenic acid; steroid glycosides, e.g., torvosides A-G), constituting a major part of its demonstrated antioxidant capacity, which is well documented using its numerous *in-vitro* assays.

In addition to antioxidant activity, *S. torvum* extracts have a wide range of possible bioactivities, including anti-inflammatory, anti-ulcer, antimicrobial, hepatoprotective, and neuroprotective activity. These polyfunctional actions highlight its traditional medical relevance and explore possible use in integrative health systems. In spite of strong *in-vitro* studies, there exists a gap in clinical trials and an accurate mechanistic explanation. Furthermore, differences in plant, geographic, seasonal, and processing activities may greatly impact standardization for therapeutic employment.

Conclusion

S. torvum is a potential source of natural antioxidants and phytotherapeutic agents. Further research should focus on bioassay-guided isolation of active constituents, toxicological profiling, and development of a standardized formulation for clinical evaluation.

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