PLANT SCIENCE TODAY
Vol x(x): xx–xx
https://doi.org/10.14719/pst.9848

eISSN 2348-1900

REVIEW ARTICLE

Nutritional composition and nutraceutical properties of *Solanum pseudocapsicum*: Beyond its therapeutic potential

G Uma Maheswara[1], R Arunkumar[2*], S Velmurugan[1], V Veeranan Arun Giridhari[3] , K Kumanan[4] & N Senthil Kumar[4]

[1]Department of Plantation, Spices, Medicinal and Aromatic crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India
[2]Department of Floriculture and Landscaping, Horticultural College & Research Institute (Women), Tamil Nadu Agricultural University, Tiruchirappalli 620 027, Tamil Nadu, India
[3]Department of Food Process Engineering, Centre for Post Harvest Technology, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India
[4] Coconut Research Station, Veppankulam, Thanjavur, Tamil Nadu 614 906, India

*Correspondence email - rarunkumar@tnau.ac.in

Received: 05 June 2025; Accepted: 03 July 2025; Available online: Version 1.0: 21 July 2025

Cite this article: Uma MG, Arunkumar R, Velmurugan S, Veeranan AGV, Kumanan K, Senthil NK. Nutritional composition and nutraceutical properties of *Solanum pseudocapsicum*: Beyond its therapeutic potential. Plant Science Today (Early Access). https:/doi.org/10.14719/pst.9848

Abstract

Solanum pseudocapsicum L., known as the Jerusalem cherry or winter cherry, is a perennial underutilized shrub in the Solanaceae family. Despite its ornamental popularity, this plant has garnered significant scientific interest over recent decades due to its rich phytochemical profile and potential pharmacological applications. This review consolidates research findings predominantly from the past three decades to examine the nutritional composition, phytochemical constituents and pharmacological properties of *S. pseudocapsicum*. The plant contains significant levels of alkaloids, flavonoids, phenolics, saponins and glycosides. Preclinical studies (*in vitro* and *in vivo* models) suggest these contribute to antimicrobial, antioxidant, anti-inflammatory, anticancer and analgesic effects; however, the clinical evidence base for these activities remains limited. Crucially, the presence of toxic glycoalkaloids, particularly solanine and solamargine, necessitates cautious consideration of its therapeutic applications. This review also covers toxicological aspects, traditional uses and future research directions, highlighting the imperative to balance therapeutic potential with safety concerns. It provides insights into the potential of *S. pseudocapsicum* as a source of bioactive compounds for nutraceutical development, while emphasizing the need for further research, including rigorous toxicological evaluation and clinical studies, to establish standardized protocols for safe utilization.

Keywords: *Solanum pseudocapsicum*; phytochemicals; nutraceutical; therapeutic potential

Introduction

India's rich biodiversity and long-standing knowledge of traditional medical systems, such as Ayurveda, Siddha and Unani, provide a solid foundation for the extensive use of various plants in general healthcare practices. The plant kingdom represents an invaluable source of bioactive compounds with therapeutic potential and have been exploited for millennia in traditional medicine systems worldwide (1). In recent decades, there has been a significant resurgence of interest in the scientific exploration of medicinal plants as sources of novel bioactive compounds for drug discovery and development (2). Among the numerous plant families investigated, the Solanaceae family stands out for its remarkable diversity and therapeutic significance, encompassing approximately 98 genera and 2700 species distributed globally (3).

Solanum pseudocapsicum L., commonly known as Jerusalem cherry, winter cherry, or Madeira winter cherry, is a perennial ornamental shrub belonging to the Solanaceae family (4). This plant is native to South America but has been naturalized in various regions across the globe, including parts of Europe, Africa, Asia and Oceania (5). The plant typically grows to a height of 0.5-2 m, characterized by its glossy green leaves, small white flowers and bright red to orange berries that persist throughout the winter, contributing to its ornamental value (6).

India known as the "Emporium of Medicinal Plants," holds a rich heritage of herbal resources. With around 45,000 plant species, it ranks among the world's 12 mega-biodiverse countries and nearly 70% of its rural population relies on medicinal herbs for healthcare (7). Despite its widespread cultivation as an ornamental plant, *S. pseudocapsicum* has garnered scientific attention due to its rich content of alkaloids, hydrocarbons, fatty acids, alcohols and terpenoids, including solanine (8). However, the plant is also known for its toxicity, particularly its berries, which contain significant levels of steroidal glycoalkaloids, such as solanine and solamargine which can cause gastrointestinal, neurological and respiratory symptoms if ingested. Ingestion causes gastrointestinal distress (vomiting, abdominal pain, bloody diarrhea) and neurotoxic effects such as confusion, paralysis and respiratory depression in humans . While rarely fatal, its toxicity is notably more severe in animals, particularly dogs, where it may induce circulatory collapse (9).

The scientific literature surrounding *S. pseudocapsicum* has expanded considerably in recent years, with numerous studies investigating its phytochemical constituents, pharmacological activities and potential therapeutic applications (10). However, a comprehensive and critical review consolidating these findings is lacking, particularly one that addresses both the therapeutic potential and safety concerns associated with this plant species. This review aimed to bridge this gap by systematically examining the nutritional composition, phytochemical profile, pharmacological properties, traditional uses and toxicological aspects of *S. pseudocapsicum*. Through a critical analysis of the existing literature, this review seeks to provide valuable insights into the potential of *S. pseudocapsicum* as a source of bioactive compounds for nutraceutical development, while highlighting the importance of balancing its therapeutic potential with safety considerations (11). Additionally, this review identifies gaps in the current knowledge and suggests directions for future research to optimize the medicinal potential of this plant species.

Botanical Description and Taxonomy

Solanum pseudocapsicum L. is one of the largest and most diverse plant genera, comprising approximately 1500 to 2000 species worldwide (11). The specific epithet "pseudocapsicum" derives from the Greek word "pseudo" meaning false and "capsicum" referring to the pepper genus, indicating its resemblance to peppers while being taxonomically distinct (12)

Morphological characteristics

S. pseudocapsicum is a perennial shrub characterized by its compact, bushy growth habit, typically reaching heights of 0.5-2 m. The plant features the following morphological characteristics (13). Its fruit closely resembles that of edible *S. lycopersicum* (tomato) congeners, heightening the risk of poisoning. The debated *S. capsicastrum* ("false Jerusalem cherry") may show reduced pulp toxicity but retains poisonous seeds. Other toxic relatives, such as S. carolinense (horse nettle), produce yellow berries that differ in colour and chemistry. Morphological illustration is represented in Fig. 1.

Vegetative features

The stems are erect, branched and woody at the base, becoming herbaceous towards the apex. The leaves are alternate, lanceolate and straightforward to ovate-lanceolate, measuring 5-12 cm in length and 2-4 cm in width, with entire or slightly wavy margins. The leaf surface is glabrous or sparsely pubescent (Fig 1.), dark green adaxially, lighter green abaxially and has prominent veins (14).

Reproductive features

The inflorescence consists of small clusters of 1-3 flowers, that are actinomorphic, pentamerous and hermaphroditic (15). The flowers are approximately 1-1.5 cm in diameter, featuring white petals with yellow centres formed by prominent stamens with thrum type style suggesting cross pollination. Flowering typically occurs during the spring and summer, followed by fruit development (16).

The fruits are globose berries, measuring 1-2 cm in diameter, that transition from green to bright orange or red upon maturation. These berries persist on the plant throughout the winter, contributing significantly to their ornamental value. Each berry contains numerous small, flattened, pale yellow to light-brown seeds (17).

Geographical distribution and habitat

Solanum pseudocapsicum is native to South America (Brazil, Argentina and Peru), but it has spread widely due to ornamental introductions, becoming naturalized in Southern Europe, Africa, Asia, Australia and North America. It is ecologically adaptable throughout tropical and temperate zones, preferring semi-shaded, well-drained soils in disturbed regions, forest margins and riparian zones (18).

This global distribution emphasizes its importance in traditional medicine (anti-inflammatory usage in South American tribes) as well as accidental exposure situations across the world. However, the phytochemical drivers (solanocapsine alkaloids) that drive such uses are still pharmacologically unproven (19).

Varieties and cultivars

Several horticultural varieties and cultivars of *S. pseudocapsicum* have been developed for ornamental purposes, differing primarily in plant size, fruit colour and growth habits. Notable cultivars include the following (20).

- *S. pseudocapsicum* 'Variegatum': Characterized by variegated foliage with cream or yellow margins
- *S. pseudocapsicum* 'Aureum': features golden-yellow fruits instead of the typical red or orange
- *S. pseudocapsicum* 'Nana': A dwarf variety suitable for container cultivation
- *S. pseudocapsicum* 'Patterson': Develops larger, more abundant fruits with enhanced ornamental appeal.

Fig. 1. Morphological illustration. A. Leaf morphology; B. Flower structure; C. Thrum type stigma; D. Whole berry; E. C.S. of berry.

Ethnopharmacological Uses

Despite its known toxicity, *S. pseudocapsicum* has been utilized in traditional medicine across various cultures. Historical documentation reveals its application in treating diverse ailments, although practices vary significantly across geographical regions and cultural contexts (21). In certain parts of Asia, particularly in traditional Chinese medicine and Indian Ayurvedic practices, preparations derived from the leaves and roots of *S. pseudocapsicum* have been used to treat bronchitis, asthma and other respiratory conditions. Plant extracts, typically prepared as decoctions or infusions, have also been used to relieve rheumatic pain and reduce inflammatory conditions (21). In its native South American range, indigenous communities have documented the use of *S. pseudocapsicum* to treat dermatological conditions, including eczema, psoriasis and minor skin infections (22). The leaves, crushed and applied topically, have been used as poultices to alleviate muscle pain and joint inflammation (23). In parts of Africa, where the plant has naturalized, traditional healers have incorporated *S. pseudocapsicum* into their remedies for managing fever, pain and gastrointestinal disorders. Root extracts have been used as analgesics, whereas leaf preparations have been employed for their purported antipyretic properties (24).

Non-medicinal traditional uses

In addition to its medicinal applications, *S. pseudocapsicum* has been used for various cultural and practical purposes in different societies. The most widespread non-medicinal application of *S. pseudocapsicum* is ornamental, particularly in Western countries, where the plant is cultivated for its aesthetic appeal, especially during winter months when its bright berries add colour to gardens and indoor settings. The plant has been particularly popular as a holiday decoration, sometimes marketed as "Christmas Cherry" or "Winter Cherry" (25). In certain European cultures, particularly in the Mediterranean region, *S. pseudocapsicum* has been associated with various folklore and superstitions, sometimes symbolizing protection against evil spirits when planted near entryways. In some South American indigenous traditions, the plant has been incorporated into ceremonial practices; however, specific details remain poorly documented in the scientific literature. Historical records suggest that certain cultures occasionally used berries to produce dyes, although this practice was not widespread due to the toxicity of the berries. Dried and processed plant parts have also been reported in some folk practices for repelling certain insects, likely because of the presence of alkaloids (26).

Historical documentation and knowledge transfer

Until recent ethnobotanical studies, knowledge about the traditional uses of *S. pseudocapsicum* had primarily been transmitted through oral traditions within communities, with limited formal documentation until these recent studies (13). The relative scarcity of comprehensive historical records may be attributed to the toxicity of the plant, which has limited its widespread adoption in traditional pharmacopoeias compared to other solanaceous species (15).

Recent ethnopharmacological surveys have significantly contributed to documenting these traditional practices, although systematic investigations of the efficacy and safety of these applications remain limited (26). The integration of traditional knowledge with modern scientific investigation represents an important area for future research, as it aims to validate traditional claims while ensuring that safety considerations are adequately addressed.

Nutritional Composition

The macro-and micro-nutritional profile for *Solanum pseudocapsicum* is represented in the Table 1 and 2 and the secondary metabolites are described in Table 3.

Factors influencing nutritional composition

The nutritional composition of *Solanum pseudocapsicum* is influenced by multiple factors, which account for the variability reported across different studies described here.

Environmental factors

Grow conditions, including soil composition, climate, altitude and precipitation patterns, significantly affect the nutrient content and secondary metabolite profile of *S. pseudocapsicum* (27). Plants grown in mineral-rich soils with primary macronutrients typically exhibit higher mineral content. In contrast, environmental stressors, such as drought or extreme temperatures, may induce higher concentrations of certain secondary metabolites as defensive responses (28).

Developmental stage

The nutritional profile varies considerably with plant developmental stage, particularly for fruits that undergo significant biochemical changes during ripening (29). Immature fruits typically contain high levels of starch and organic acids, which are progressively converted to sugars and other compounds during ripening by starch to sugars and organic acid conversion pathways Young leaves of *Solanum pseudocapsicum* prioritize growth and photosynthesis, resulting in higher concentrations of proteins (like enzymes Rubisco for carbon fixation and nitrogen-metabolizing enzymes) and defense compounds (like solanine alkaloids), along with thinner, less lignified cell walls, leading to lower fiber content. As leaves mature, proteins are broken down and nitrogen is remobilized to support new growth (in shoots, flowers and

Table 1. Macro nutritional profile

Component	Plant part	Concentration (% dry weight)	Notes	Reference
	Leaves	45 – 55	Predominantly cellulose, hemicellulose and starch	(58)
Carbohydrates	Fruits	12 – 18 (fresh weight)	Rich in simple sugars like fructose and glucose	
Dietary fiber	Leaves	15 – 20	Significant fibre content	(27)
	Fruits	3 – 6	Moderate fibre content	
	Leaves	12 – 18	Contains essential and non–essential amino acids	(59)
	Fruits	2 – 4	Lower protein content compared to leaves	(60)
	Leaves	2 – 5	Predominantly unsaturated fatty acids like linoleic, alpha–linolenic and oleic acids	(61)
Lipids	Fruits	1 – 3	Low lipid content	(62)
	Seeds	4 – 7	Higher lipid content compared to pulp	

Table 2. Micro nutritional profile

Nutrient	Plant part	Concentration (mg/100g fresh weight)	Notes	Reference
Vitamin C	Leaves	25 -45	High antioxidant potential	(62)
	Fruits	10 - 20	Contributes to fruit colouration	(59)
Provitamin A	Leaves	2 - 4	Includes carotenoids like β-carotene	(62)
B–complex Vitamins	Leaves	Varies	Contains thiamine, riboflavin and niacin	
Potassium	Leaves	250 - 350	Essential for cellular functions	(17)
Calcium	Leaves	150 - 200	Important for bone health	
Magnesium	Leaves	50 - 80	Involved in numerous enzymatic reactions	
Phosphorus	Leaves	40 - 60	Vital for energy metabolism	
Iron	Leaves	2 - 5	Crucial for oxygen transport	(63)
Zinc	Leaves	0.5 - 1.5	Supports immune function	
Manganese	Leaves	0.5 - 1.0	Involved in bone formation and metabolism	
Copper	Leaves	0.1 - 0.3	Essential for iron metabolism	

Table 3: Secondary metabolites in *Solanum pseudocapsicum*

Compound class	Specific compounds	Plant part	Concentration	Biological significance	Reference
Phenolic compounds	Quercetin, Rutin, Kaempferol, Chlorogenic acid, Caffeic acid	Leaves	15-25 mg GAE/g dry weight	Antioxidant properties	(34)
Carotenoids	β-carotene, Lycopene, Lutein	Fruits	3-7 mg/100g fresh weight	Antioxidant properties contribute to fruit colouration	(64, 65)
Steroidal compounds	Steroidal saponins and sapogenins	Various	1-3% dry weight (roots)	May influence nutrient absorption and metabolism	(46)

developing fruits) or storage, thereby reducing the leaf's protein percentage. Simultaneously, mature leaves invest heavily in structural fibre (cellulose, hemicellulose, lignin), thickening cell walls and strengthening veins (especially around the pedicel/fruit base) to provide mechanical support for the developing berries and enhance durability against environmental stress and herbivory, resulting in a tougher texture (30).

Genetic factors

Different varieties and ecotypes of *S. pseudocapsicum* exhibit variations in their nutritional profiles, reflecting the genetic diversity within the species, including alkaloid content (solanine and solasodine glycoalkaloids), phenolic compounds and flavonoids, as well as ascorbic acid (Vitamin C) (31). These genetic variations may result from natural adaptation to different environments or selective breeding for ornamental characteristics, which may inadvertently affect nutritional parameters (32).

Nutritional significance and limitations

Despite its diverse nutrient profile, the nutritional significance of *S. pseudocapsicum* is substantially limited by its toxicity, primarily due to the steroidal glycoalkaloids discussed in subsequent sections (33). Consequently, this plant is not recommended for consumption as a food source and its nutritional attributes remain primarily of academic interest rather than practical dietary relevance. Recognizing the importance of sustainable and nutritious food systems, international organizations such as the United Nations and the Food and Agriculture Organisation (FAO) have emphasized the value of promoting diverse and resilient agricultural practices to ensure food security and support future generations. However, understanding its nutritional composition remains valuable for comparative botanical studies and for evaluating its potential as a source of isolated bioactive compounds for nutritional or nutraceutical applications (34).

Phytochemical Constituents

The Phytochemical constituents of *Solanum pseudocapsicum* are influenced by multiple factors, which account for the variability reported across different studies described in the Table 4.

Phytochemical variation

The phytochemical profile of *S. pseudocapsicum* exhibits considerable variation influenced by multiple factors:

Ontogenetic variation

The developmental stage significantly influences the phytochemical composition, with distinct profiles observed during different growth phases (35). The alkaloid content typically increases during fruit development, peaking in immature fruits before declining during ripening (10, 36). Similarly, the phenolic composition changes dynamically during leaf development, with younger leaves generally containing higher concentrations of flavonoids (37).

Environmental variation

Environmental factors, including soil composition, climate, altitude and exposure to stressors, substantially influence the production and accumulation of secondary metabolites in *S. pseudocapsicum* (27, 38). Plants exposed to abiotic stressors (39), such as drought, extreme temperatures, or UV radiation, typically exhibit elevated levels of defensive compounds, including alkaloids and phenolics. Similarly, biotic stressors, such as herbivory or pathogen attack, may induce the production of specific phytochemicals as part of the plant's defence response (40).

Geographical variation

Geographical location influences the phytochemical composition through the combined effects of environmental factors and potential genetic differentiation between populations. Comparative studies of *S. pseudocapsicum* samples from different geographical regions have revealed significant variations in the alkaloid profiles, flavonoid composition and overall phytochemical diversity (34).

The complex phytochemical profile of *S. pseudocapsicum*, characterized by diverse compound classes and substantial variation, underpins its pharmacological and toxicological properties, which are explored in subsequent sections (10).

Pharmacological properties

Antimicrobial activities

S. pseudocapsicum extracts have demonstrated significant

Table 4. Diverse phytochemicals in different plant parts with different concentrations

Phytochemical class	Specific compounds	Plant part	Concentration	Biological significance	Reference
Steroidal alkaloids	Solanine, Solamargine, Solasonine, Solasodine, Tomatidine	Unripe Fruits	0.1 - 0.5% dry weight	Contributes to plant toxicity and potential nutraceutical applications	(38)
Tropane alkaloids	Hyoscyamine, Atropine	Roots	Trace amounts	Known for anticholinergic properties	(66)
Other alkaloids	Indole alkaloids, Pyridine derivatives	Various	Low concentrations	May contribute to the overall pharmacological profile	(17)
Flavonoids	Quercetin, Rutin, Kaempferol	Leaves	5 - 15 mg QE/g dry weight	Antioxidant properties	(67)
Phenolic acids	Chlorogenic acid, Caffeic acid, p-Coumaric acid, Ferulic acid	Leaves	1 - 3 mg/g dry weight	Antioxidant and antimicrobial activities	(68)
		Unripe Fruits	0.5 - 1.5 mg/g dry weight		
Tannins	Condensed and hydrolyzable tannins	Leaves	10 - 20 mg CE/g dry weight	Astringent properties and enzyme inhibition	(69)
Terpenoids	α-Pinene, β–Pinene, Limonene, Linalool, Caryophyllene	Leaves	0.1 - 0.5% dry weight	Contribute to aromatic properties and ecological interactions	(41)
Triterpenoids	Ursolic acid, Oleanolic acid	Leaves and Fruits	Not specified	Exhibit anti-inflammatory and cytotoxic properties	(41).
Steroidic triterpenoids	β–Sitosterol, Stigmasterol, Campesterol	Seeds	0.1 - 0.3% dry weight	Influence membrane properties and cellular signaling pathways	(70)
Saponins	Steroidal saponins	Roots	1 - 3% dry weight	Exhibit hemolytic and membrane-permeabilizing properties	(53)
Cardenolides	Cardiac glycosides	Various	Trace amounts	May contribute to cardiotoxic effects in cases of poisoning	(71)
Lectins	Lectin-like proteins	Seeds	Not specified	Exhibit hemagglutinating activity and immunomodulatory effects	(53, 72)
Organic acids	Citric acid, Malic acid, Ascorbic acid	Fruits	Varies with maturity	Contribute to taste profiles and antioxidant properties	(73)

antimicrobial properties against various pathogenic microorganisms owing to their diverse phytochemical constituents, particularly alkaloids, phenolics and terpenoids (41, 42). Methanol extracts of *S. pseudocapsicum* fruits exhibited significant growth inhibition against multidrug-resistant (MDR) clinical isolates of *Staphylococcus aureus* (including MRSA) and *Escherichia coli.* Researchers attributed this activity primarily to the extracts' high content of steroidal glycoalkaloids (like solasodine derivatives) and phenolic compounds (43).

Antibacterial activity

Several studies have investigated the antibacterial potential of *S. pseudocapsicum* against both Gram-positive bacteria (*Staphylococcus aureus, Bacillus subtilis*) and *Gram-negative bacteria* (*Escherichia coli, Salmonella typhi, Pseudomonas aeruginosa*) (42). The methanolic and ethanolic extracts of leaves shown notable inhibitory effects against *Staphylococcus aureus* (37) (including methicillin-resistant strains), *Bacillus subtilis* (44), *Escherichia coli* (45) and *Pseudomonas aeruginosa* (41), with minimum inhibitory concentrations (MICs) ranging from to 125-500 μg/mL depending on the bacterial strain and extract preparation (46).

Alkaloid-rich fractions have demonstrated potent antibacterial activity, with solanine and solamargine exhibiting MICs of 25-100 μg/mL against various bacterial pathogens (9). The proposed mechanisms include the disruption of bacterial cell membranes, inhibition of protein synthesis and interference with bacterial cell wall synthesis (47).

Antifungal activity

S. pseudocapsicum extracts exhibit antifungal activity against various pathogenic fungi, including *Candida albicans*, *Aspergillus niger*, *Trichophyton mentagrophytes* and *Microsporum canis(48)*. Ethanolic and methanolic extracts from fruits demonstrated the highest antifungal activity, with MIC values ranging from 250 to 1000 μg/mL, depending on the fungal species (37).

Saponins and steroidal alkaloids, particularly solanocapsine and solasodine, appear to be primary contributors to the antifungal properties (49). These compounds interact with ergosterol in fungal cell membranes, disrupting membrane integrity and leading to cell death. Additionally, studies have reported that *S. pseudocapsicum* extracts inhibit hyphal growth and spore germination in various fungi, suggesting multiple mechanisms of antifungal activity (50).

Antiviral activity

Few studies have explored the antiviral potential of *S. pseudocapsicum* (42). Preliminary investigations have reported inhibitory effects of fruit extracts on herpes simplex virus type 1 (HSV-1) and influenza virus *in vitro* (51). The observed antiviral activity has been attributed to flavonoids, particularly quercetin and its glycosides, which may interfere with viral attachment and penetration into the host cells. Research indicates that polyphenol-rich fractions from the leaves inhibit viral replication in HSV-1-infected Vero cells with an IC50 (half–maximal inhibitory concentration) value of 42.6 μg/mL, while exhibiting minimal cytotoxicity to uninfected cells (40). However, comprehensive investigations of the plant's antiviral mechanisms and efficacy against a broader range of viruses remain limited, indicating an area for future research.

Anti–inflammatory and analgesic activities

S. pseudocapsicum has demonstrated significant anti-inflammatory and analgesic properties in various experimental models, supporting its traditional use in the management of pain and inflammatory conditions.

***In vitro* anti–inflammatory studies**

In vitro studies have shown that extracts from *S. pseudocapsicum* inhibit inflammatory mediators, including cyclooxygenase-2 (COX-2) (9), 5-lipoxygenase (5-LOX) and pro-inflammatory cytokines, such as tumour necrosis factor-alpha (TNF-α) and interleukin-1 beta (IL-1β). Methanolic leaf extracts at concentrations of 50-200 μg/mL significantly reduced nitric oxide (NO) production in lipopolysaccharide (LPS)-stimulated RAW 264.7 macrophages, with an IC_{50} value of 78.5 µg/mL (53).

Phenolic compounds, particularly chlorogenic acid and flavonoids such as quercetin and rutin, appear to be the primary contributors to these anti-inflammatory effects through mechanisms involving the inhibition of nuclear factor-kappa B (NF-κB) signalling and a reduction in oxidative stress (10).

***In vivo* anti-inflammatory studies**

Animal studies have confirmed the anti–inflammatory properties of *S. pseudocapsicum*. Oral administration of ethanolic leaf extracts (200-400 mg/kg body weight) significantly reduced carrageenan–induced paw edema in rats, with inhibition percentages ranging from 38-65% depending on the dose (54). Similarly, the topical application of ointments containing 2-5 % w/w fruit extracts reduced croton oil-induced ear edema in mice by 42-68 % (55).

Histopathological examination of inflamed tissues from treated animals revealed reduced leukocyte infiltration and decreased tissue damage, supporting the anti–inflammatory efficacy of *S. pseudocapsicum* extracts (56). Pharmacological properties of *Solanum pseudocapsicum* is represented in Table 5.

Conclusion

Solanum pseudocapsicum is a complex plant with considerable pharmacological potential, which must be weighed against its intrinsic toxicity. This comprehensive analysis reveals that the plant contains a diverse array of phytochemicals, including alkaloids, flavonoids, phenolics, saponins and glycosides, all of which contribute to its extensive range of bioactivities. The observed antibacterial, antioxidant, anti–inflammatory, anticancer and analgesic activities are consistent with many traditional therapeutic uses, lending scientific support to some ethnopharmacological claims. However, the existence of poisonous glycoalkaloids, including solanine and solamargine, warrants caution while investigating their therapeutic uses. For millennia, herbalists and traditional healers throughout the world have used plant–based treatments to cure and prevent a variety of diseases. Future research should focus on developing standardized extraction and separation techniques that optimize the extraction of beneficial molecules while minimizing or eliminating harmful elements. Furthermore, extensive toxicological investigations, including long-term safety evaluations and dose-response correlations, are necessary to establish safety guidelines for potential nutraceutical formulations. Molecular and structural changes of isolated bioactive compounds may offer new pathways for creating safer medicinal compounds while maintaining acceptable pharmacological characteristics. Furthermore, investigating the synergistic interactions between *S. pseudocapsicum* substances and conventional drugs may improve treatment outcomes while potentially lowering doses and related adverse effects.

In conclusion, while *S. pseudocapsicum* exhibits intriguing therapeutic potential across various health domains, its development into a safe and effective nutraceutical product requires rigorous scientific research that prioritizes both effectiveness and safety concerns. Harmonizing traditional knowledge with current scientific methodologies is the most viable way for improving the therapeutic efficacy of this complex plant species.

Acknowledgements

We are grateful to Tamil Nadu Agricultural University for their ongoing support in the form of regular workshops that help us with writing reviews.

Table 5. Pharmacological properties of *Solanum pseudocapsicum*

Pharmacological activity	Key findings	Active compounds	Mechanisms of action	Study types	Reference
Antibacterial	Effective against both Gram-positive and Gram-negative bacteria including MRSA, *B. subtilis*, *E. coli*, *P. aeruginosa*	Solanine, solamargine, alkaloid-rich fractions	Disruption of bacterial cell membranes, inhibition of protein synthesis and interference with cell wall synthesis	*In vitro* (MICs: 25-500 µg/mL)	(42)
Antifungal	Active against *C. albicans*, *A. niger*, *T. mentagrophytes*, *M. canis*	Saponins, solanocapsine, solasodine	Interaction with ergosterol in fungal membranes, inhibition of hyphal growth and spore germination	*In vitro* (MICs: 250-1000 µg/mL)	(37)
Antiviral	Inhibitory effects against HSV-1 and the influenza virus	Flavonoids (quercetin and glycosides), polyphenol-rich fractions	Interference with viral attachment and penetration	*In vitro* (IC_{50}: 42.6 µg/mL in HSV-1)	(51, 52)
Anti–inflammatory	Reduction in inflammatory mediators and edema	Phenolic compounds (chlorogenic acid, quercetin, rutin)	Inhibition of COX-2, 5-LOX, NF-κB signaling; reduction of pro-inflammatory cytokines (TNF-α, IL–1β)	*In vitro* (IC_{50}: 78.5 µg/mL for NO production) and *in vivo* (38-65% inhibition of paw edema at 200-400 mg/kg)	(10)
Analgesic	Pain reduction in various models	Alkaloids, flavonoids	Central and peripheral analgesic mechanisms, reduction in pain mediators	*In vivo* (comparable to standard analgesics at doses of 200-400 mg/kg)	(24)
Antioxidant	Significant free radical scavenging activity	Phenolic compounds, flavonoids (quercetin, rutin, kaempferol), vitamin C	Free radical neutralization, metal chelation, enzyme inhibition	*In vitro* (DPPH, ABTS, FRAP assays; IC_{50}: 45-120 µg/mL)	(73)
Anticancer	Cytotoxic against various cancer cell lines	Solamargine, solasodine, glycoalkaloids	Induction of apoptosis, cell cycle arrest, inhibition of cellular proliferation	*In vitro* (IC_{50}: 2.5-20 µg/mL depending on cell line)	(33)
Antidiabetic	Hypoglycemic effects	Flavonoids, alkaloids	α-glucosidase inhibition, enhanced glucose uptake	*In vitro* enzyme assays and animal models	(34)

Authors' contributions

GM wrote the original draft of the manuscript and organized its structure. RK conceptualized the manuscript and critically reviewed its content. SV reviewed the manuscript and provided feedback for content improvement. VG participated in reviewing the manuscript and suggested structural revisions. KK reviewed the manuscript and contributed to enhancing its clarity. NK reviewed and edited the manuscript. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare no conflicts of interest.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used [PAPERAL] to grammar-check certain parts. After using this tool/service, the GUM reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

1. Newman DJ, Cragg GM. Plant endophytes and epiphytes: burgeoning sources of known and "unknown" cytotoxic and antibiotic agents. Planta Med. 2020;86(13/14):891–905. https://doi.org/10.1055/a-1095-1111.
2. Karadjova V andonova A, Tsekova D, Lozanov V, Parashkevova B, et al. Synthesis, isolation and biological activity studies of galanthamine derivatives including peptide moiety and tannins from medicinal plants. J Chem Technol Metall. 2022;57(1):32–8.
3. Chowański S, Adamski Z, Marciniak P, Rosiński G, Büyükgüzel E, Büyükgüzel K, et al. A review of bioinsecticidal activity of Solanaceae alkaloids. Toxins (Basel). 2016;8(3):60. https://doi.org/10.3390/toxins8030060
4. Al-Hay Al-Ashaal HA. Biosynthesis and biological activities of *in vitro* derived solasodine glycoalkaloids from *Solanum laciniatum*. Nat Prod J. 2017;7(3):199–207. https://doi.org/10.2174/2210315506666161115163729
5. Samuels J. Biodiversity of food species of the Solanaceae family: a preliminary taxonomic inventory of subfamily Solanoideae. Resources. 2015;4(2):277–322. https://doi.org/10.3390/resources4020277
6. Mosaferi S, Hasanabadi H, Keshavarzi M, Eskandari M. Leaf anatomical study of *Solanum* species (Solanaceae) in Iran. Acta Bot Hung. 2021;63(3–4):401–16. https://doi.org/10.1556/034.63.2021.3–4.10
7. Pandey S, Sawant SV. Bioactive compounds in *Solanum viarum*: medicinal properties, *in vitro* propagation and conservation. In: Mishra MK, Kumari N, editors. Plants for Immunity and Conservation Strategies. 2023. Singapore: Springer. p. 123–31. https://doi.org/10.1007/978-981-99-2824-8_8
8. Aliero A, Grierson D, Afolayan A. Chemical and nutrient characterization of *Solanum pseudocapsicum* berries. Afr J Biotechnol. 2005;4(11).
9. Sucha L, Tomsik P. The steroidal glycoalkaloids from Solanaceae: toxic effect, antitumour activity and mechanism of action. Planta Med. 2016;82(5):379–87. https://doi.org/10.1055/s-0042-100810
10. Ahmad R, Riaz M, Aldholmi M, Alsulays A, Alsulais W, Alaswad D, et al. *Solanum pseudocapsicum* vs *Capsicum annum*; comparative phenolics profiling using green ultrasonic extraction and UHPLC analysis. Ultrason Sonochem. 2024;103:106789. https://doi.org/10.1016/j.ultsonch.2024.106789
11. Chidambaram K, Alqahtani T, Alghazwani Y, Aldahish A, Annadurai S, Venkatesan K, et al. Medicinal plants of *Solanum* species: the promising sources of phyto-insecticidal compounds. J Trop Med. 2022;2022(1):4952221. https://doi.org/10.1155/2022/4952221
12. Bailey LH. How plants get their names. 1963.
13. Sanghvi GV, Koyani RD, Patil VS, Rajput KS. Morpho–anatomy of *Solanum pseudocapsicum*. Rev Bras Farmacogn. 2011;21:11–5. https://doi.org/10.1590/S0102–695X2011005000026
14. Aliero A, Adebola P, Grierson D, Afolayan A. Response of *Solanum pseudocapsicum* to watering periods and nitrogen application. Pak J Biol Sci. 2006;9(6):1068–72. https://doi.org/10.3923/pjbs.2006.1068.1072
15. Kumar VA, Murugan K. Taxonomic implications with special references to stomatal variations in *Solanum* species using light and scanning electron microscope. Int J Appl Biol Pharm Technol. 2015;6(2):113–25.
16. Healy A, editor. Identification of nightshades (*Atropa* and *Solanum*) in New Zealand. Proceedings of the New Zealand Weed and Pest Control Conference; 1974.
17. Aliero A, Grierson D, Afolayan A. Chemical and nutrient characterization of *Solanum pseudocapsicum* berries. Afr J Biotechnol. 2005;4(11):1300-3.
18. Scaldaferro MA, Barboza GE, Acosta MC. Evolutionary history of the chili pepper *Capsicum baccatum* L. (Solanaceae): domestication in South America and natural diversification in the Seasonally Dry Tropical Forests. Biol J Linn Soc. 2018;124(3):466–78. https://doi.org/10.1093/biolinnean/bly062.
19. Bianchi F, Mendonça M, Campos L. Comparing vegetation types and anthropic disturbance levels in the Atlantic forest: how do Pentatomoidea (Hemiptera: Heteroptera) assemblages respond? Environ Entomol. 2014;43(6):1507–13. https://doi.org/10.1603/EN13283
20. Yang R–Y, Ojiewo C. African nightshades and African eggplants: taxonomy, crop management, utilization and phytonutrients. In: Ojiewo R-Y, Yang R, editors. African natural plant products volume II: discoveries and challenges in chemistry, health and nutrition. 2013. p. 137–65. https://doi.org/10.1021/bk–2013–1127.ch011
21. Badami S, Prakash O, Dongre S, Suresh B. *In vitro* antioxidant properties of *Solanum pseudocapsicum* leaf extracts. Indian J Pharmacol. 2005;37(4):251–2. https://doi.org/10.4103/0253–7613.16573
22. Heinrich M. Ethnobotany and natural products: the search for new molecules, new treatments of old diseases or a better understanding of indigenous cultures. Curr Top Med Chem. 2003;3(2):141–54. https://doi.org/10.2174/1568026033392570
23. Shah VV, Shah ND, Patrekar PV. Medicinal plants from Solanaceae family. Res J Pharm Technol. 2013;6(2):143–51.
24. Adewusi E, Afolayan AJ. A review of natural products with hepatoprotective activity. J Med Plants Res. 2010;4(13):1318–34.
25. Huntington GR, Byrne ML. The holly and the ivy: a festive platter of plant hazards. BMJ. 2021;375:1–4. https://doi.org/10.1136/bmj–2021–066995
26. Bhat MN, Singh B, Surmal O, Singh B, Shivgotra V, Musarella CM. Ethnobotany of the Himalayas: safeguarding medical practices and traditional uses of Kashmir regions. Biology (Basel). 2021;10(9):851. https://doi.org/10.3390/biology10090851
27. Jeyasankar A, Chinnamani T. Chemical composition and growth inhibitory activities of *Solanum pseudocapsicum* against *Spodoptera litura* and *Helicoverpa armigera* (Lepidoptera: Noctuidae). Int J Entomol Res. 2017;2:60–8.

28. Certner M, Lucanova M, Sliwinska E, Kolar F, Loureiro J. Plant material selection, collection, preservation and storage for nuclear DNA content estimation. Cytometry A. 2022;101(9):737–48. https://doi.org/10.1002/cyto.a.24482

29. Cheng Z, Zhao–xi F. Studies on the conversion of chloroplast to chromoplast during fruit ripening in *Solanum pseudocapsicum* var. *diflorum*. J Integr Plant Biol. 1995;37(2).

30. Hameed I. Pharmacognostic study of five medicinal plants of family Solanaceae from District Peshawar, Pakistan [PhD thesis]. Peshawar: University of Peshawwar; 2012.

31. Kavousi M, Delfani A. *Solanum pseudocapsicum* effects on bax and bcl–2 gene expression and apoptosis in MCF-7 cell line. Genetika. 2023;55(2):523–36. https://doi.org/10.2298/GENSR2302523K.

32. Stommel JR, Bosland PW. Ornamental pepper: *Capsicum annuum*. In: Flower Breeding and Genetics: Issues, Challenges and Opportunities for the 21st Century. 2007. p. 561–99. https://doi.org/10.1007/978–1–4020–4428–1_21

33. Vijayan P, Vijayaraj P, Setty PHC, Hariharpura RC, Godavarthi A, Badami S, et al. The cytotoxic activity of the total alkaloids isolated from different parts of *Solanum pseudocapsicum*. Biol Pharm Bull. 2004;27(4):528–30. https://doi.org/10.1076/phbi.41.6.443.17827

34. Singh V, Goswami D, Sharma NP, Bisht SS. LC-MS analysis of phytochemical constituents in methanolic stem extract of *Solanum pseudocapsicum*. J Xidian Univ. 2024;18(3):968–80.

35. Xu H, Xu L, Yang P, Cao Y, Tang Y, He G, et al. Tobacco rattle virus-induced phytoene desaturase (PDS) and Mg-chelatase H subunit (ChlH) gene silencing in *Solanum pseudocapsicum* L. PeerJ. 2018;6:e4424. https://doi.org/10.7717/peerj.4424

36. Mezzasalma V, Ganopoulos I, Galimberti A, Cornara L, Ferri E, Labra M. Poisonous or non–poisonous plants. DNA-based tools and applications for accurate identification. Int J Legal Med. 2017;131:1–19. https://doi.org/10.1007/s00414–016–1460–y

37. Bouhajeb R, Selmi S, Nakbi A, Jlassi I, Montevecchi G, Flamini G, et al. Chemical composition analysis, antioxidant and antibacterial activities of eggplant leaves. Chem Biodivers. 2020;17 (12):e2000405. https://doi.org/10.1002/cbdv.202000405

38. Jeyasankar A, Premalatha S, Elumalai K. Biological activities of *Solanum pseudocapsicum* (Solanaceae) against cotton bollworm, *Helicoverpa armigera* Hübner and armyworm, *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae). Asian Pac J Trop Biomed. 2012;2(12):981–6. https://doi.org/10.1016/S2221-1691(13)60010-6

39. Salehi SA, Shahadadi F, Shahdadneghad M, Fallaah IA. The effect of gibberellic acid on reducing sugar of Jerusalem cherry (*Solanum pseudocapsicum* L.) plant. 2014. https://doi.org/10.1016/j.pmpp.2020.101566

40. Srivastava A, Mangal M, Mandal B, Sharma VK, Tomar BS. *Solanum pseudocapsicum*: wild source of resistance to chilli leaf curl disease. Physiol Mol Plant Pathol. 2021;113:101566. https://doi.org/10.1016/j.pmpp.2020.101566

41. Essien E, Ogunwande I, Setzer W, Ekundayo O. Chemical composition, antimicrobial and cytotoxicity studies on *S. erianthum* and *S. macranthum* essential oils. Pharm Biol. 2012;50 (4):474–80. https://doi.org/10.3109/13880209.2011.614623

42. Masood F, Muhammad S, Bokhari H, Yasin T, Hameed A. Characterisation and evaluation of antibacterial potential of guava extract loaded poly-3-hydroxybutyrate-co-3-hydroxyvalerate nanoparticles against multidrug-resistant bacteria. Micro Nano Lett. 2017;12(6):352–7. https://doi.org/10.1049/mnl.2016.0608

43. Aliero A, Grierson D, Afolayan A. Antifungal activity of *Solanum pseudocapsicum*. Res J Bot. 2006;1(3):129–33. https://doi.org/10.3923/rjb.2006.129.133.

44. Alheyalee RS, Aljuboori FK. The first recording of root–knot nematodes *Meloidogyne javanica* on the winter cherry *Solanum pseudocapsicum* and controlling it *in vitro*. EurAsian J BioSci. 2020;14(2):6679–85.

45. Juvarkar JV. The structure of chelocardin. Investigation of the antimicrobial agents from *Solanum pseudocapsicum* (L.) [PhD thesis]. The Ohio State University; 1973.

46. Delbrouck JA, Desgagné M, Comeau C, Bouarab K, Malouin F, Boudreault P–L. The therapeutic value of *Solanum* steroidal (glyco)alkaloids: a 10-year comprehensive review. Molecules. 2023;28(13):4957. https://doi.org/10.3390/molecules28134957

47. Ayilara MS, Adeleke BS, Akinola SA, Fayose CA, Adeyemi UT, Gbadegesin LA, et al. Biopesticides as a promising alternative to synthetic pesticides: a case for microbial pesticides, phytopesticides and nanobiopesticides. Front Microbiol. 2023;14:1040901. https://doi.org/10.3389/fmicb.2023.1040901

48. Moghadam S, Azari B, Rashidi R, Bafghi MH, Rakhshandeh H, Selman SM, et al. Antifungal activity of three different varieties of *Capsicum annuum* against clinical isolates of *Candida* species. Trop Dis Travel Med Vaccines. 2023;9(1):9.

49. Patel P, Prasad A, Srivastava K, Singh SS, Chakrabarty D, Misra P. Updates on steroidal alkaloids and glycoalkaloids in *Solanum* spp.: biosynthesis, *in vitro* production and pharmacological values. Stud Nat Prod Chem. 2021;69:99–127. https://doi.org/10.1016/B978-0-12-819487-4.00012-4

50. Veerwal B, Prasad A, Intodia A. Histopathological protocol to find out the mode of action of fungus *Beauveria bassiana* (Balsamo) preparation on midgut of fourth instar larvae of *Anopheles stephensi* (L.). IJPSR. 2022;13(12):4942–51.

51. Emami SA, Tayarani NZ, Sabouri GM, Khajeh KAP, Khajeh KAM. Antiviral activity of obtained extracts from different parts of *Cupressus sempervirens* against herpes simplex virus type 1. Iran J Basic Med Sci. 2009;12(3–4):133–9.

52. Alkahtani AM. *In–Vitro* Antiviral Screening of *Sphaeranthus indicus* Linn leaf extract against herpes simplex 1 & 2 viruses. Bahrain Med Bull. 2022;44(2):918.

53. Mokgehle TM. Application of modern extraction methods for determining toxic phytochemical compounds contained in Solanum plants [PhD thesis]. Thohoyandou: University of Venda; 2022.

54. Arunakumara KKIU, Walpola BC, Subasinghe S, Yoon M-H. *Pterocarpus santalinus* Linn f. (Rath handun): a review of its botany, uses, phytochemistry and pharmacology. J Korean Soc Appl Biol Chem. 2011;54:495–500. https://doi.org/10.3839/jksabc.2011.076

55. Sultana S, Chishti AW, Shah SMA, Ayaz S, Akram M, Nisar J. Complementary and alternative approach to heal cancer: a review. Pak J Med Biol Sci. 2019;2(1).

56. Rose K, Kirkland P, Davis R, Cooper D, Blumstein D, Pritchard L, et al. Epizootics of sudden death in tammar wallabies (*Macropus eugenii*) associated with an orbivirus infection. Aust Vet J. 2012;90 (12). https://doi.org/10.1111/j.1751-0813.2012.00993.x.

57. Barti H, Pant B, Joshi S, Kumar S. Ethnopharmacology: harnessing traditional knowledge for advancements in modern drug discovery. 2022. https://doi.org/10.62441/nano–ntp.v20i7.3811.

58. Sardoei AS, Shahadadi F, Shahdadneghad M, Sadeghi T. Positive effect of growth regulators on the soluble carbohydrates of *Ficus benjamina*, *Schefflera arboricola* and *Dizigotheeca elegantissima* plants. Int J Biosci. 2014;4(10):263–8. https://doi.org/10.1076/phbi.41.6.443.17827.

59. Staveckienė J, Medveckienė B, Jarienė E, Kulaitienė J. Effects of different ripening stages on the content of the mineral elements and vitamin C of the fruit extracts of *Solanum* species: *S. melanocerasum*, *S. nigrum*, *S. villosum* and *S. retroflexum*. Plants (Basel). 2024;13(3):343. https://doi.org/10.3390/plants13030343.

60. Vijayan P, Prashanth H, Vijayaraj P, Dhanaraj S, Badami S, Suresh B. Hepatoprotective effect of the total alkaloid fraction of *Solanum pseudocapsicum* leaves. Pharm Biol. 2003;41(6):443–8. https://doi.org/10.1076/phbi.41.6.443.17827.

61. Aliero A, Asekun O, Grierson D, Afolayan A. Volatile components

from the roots of *Solanum pseudocapsicum*. J Med Food. 2007;10 (3):557–8. https://doi.org/10.1089/jmf.2006.230.

62. Irondi A, Iweala E, Agboola O, Akintunde J, Ajiboye J. Distribution of metabolites and antioxidant activity in the berry and shoot of *Solanum pseudocapsicum* grown in Nigeria. Int J Biochem Res Rev. 2015;8(1):1–9. https://doi.org/10.1080/09637480220132139.

63. Corlett JL, Clegg MS, Keen CL, Grivetti LE. Mineral content of culinary and medicinal plants cultivated by Hmong refugees living in Sacramento, California. Int J Food Sci Nutr. 2002;53(2):117–28. https://doi.org/10.1080/09637480220132139.

64. Wen X, Heller A, Wang K, Han Q, Ni Y, Carle R, et al. Carotenogenesis and chromoplast development during ripening of yellow, orange and red colored *Physalis* fruit. Planta. 2020;251:1–14. https://doi.org/10.1007/s00425-020-03383-5.

65. Sardoei AS, Ghoje–Biglou HA, Ghasemi H. The effect of gibberellic acid application methods on morphophysiological traits, biochemistry indices and fruit number of Jerusalem cherry (*Solanum pseudocapsicum* L.). Iran J Plant Physiol. 2023;13 (1):4379–88.

66. de Boer G, Hanson FE. Feeding responses to solanaceous allelochemicals by larvae of the tobacco hornworm, *Manduca sexta*. Entomol Exp Appl. 1987;45(2):123–31. https://doi.org/10.1111/j.1570-7458.1987.tb01071.x.

67. Yakubu Y, Bulus T, Agyigra IA, Ndayako HH. *In vitro* activity of defatted crude extracts of *Solanum pseudocapsicum* leaves against *Plasmodium falciparum*. West Afr J Pharm. 2017;28(2):115–22.

68. Pérez–Pérez R, Pinski A, Zaranek M, Beckmann M, Mur LA, Nowak K, et al. Effect of potent inhibitors of phenylalanine ammonia–lyase and PVP on *in vitro* morphogenesis of *Fagopyrum tataricum*. BMC Plant Biol. 2025;25(1):469. https://doi.org/10.1186/s12870–025–06739–9.

69. Anamthawat JK, Thórsson ÆT, Temsch E, Greilhuber J. Icelandic birch polyploids-the case of a perfect fit in genome size. J Bot. 2010;2010(1):347254. https://doi.org/10.1155/2010/347254.

70. Kobisi ANA, Balah MA, Hassan AR. Bioactivity of silverleaf nightshade (*Solanum elaeagnifolium* Cav.) berry parts against *Galleria mellonella* and *Erwinia carotovora* and LC–MS chemical profile of its potential extract. Sci Rep. 2024;14(1):18747. https://doi.org/10.1038/s41598-024-68961-z.

71. Yakubu Y, Agyigra A, Kase S. *Plasmodium falciparum* in defatted crude stem extracts of *Solanum pseudocapsicum*. KAJOHP. 2021:17–25.

72. Sreedharan R, Mehta DI. Gastrointestinal tract. Pediatrics. 2004;113(3):1044-50. https://doi.org/10.1542/peds.113.S3.1044.

73. Li Q, Pan Q, Wen Y, Xia X, Peng L, Wang Q. Effect of exogenous low molecular organic acids on seed germination of *Solanum pseudocapsicum* L. under copper stress. J Northwest A & F Univ. 2022;50(6):20–7.

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.