

Aspects of Phenolic Compounds in Pharmacological Activities of Solanum Family

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Abstract

Solanum family of plants is a large genus under the family of Solanaceae that includes up to 2,000 species, they specify from food crops, such as the potato and the tomato, to various ornamentals and medicinal species. Natural phenolic compounds mostly obtained from solanum species and play an important role in antimicrobial and antibacterial and other treatment. Phenolic compounds from solanaceae plants and dietary plants that contains grains, nut, seeds, legumes and fruits include various phenolic acids, flavonoids, tannins, stilbenes, curcuminoids, coumarins, lignans, quinines like (They divided phenolics in four groups analyzing individual compounds: hydroxycinnamic acids (chlorogenic, ferulic, caffeic, and p-coumaric), flavonols (quercetine-3-rutinoside, quercetine-3-galactoside, quercetine-3-glucoside and quercetine-3-rhamnoside), flavanols (catechin and epicatechin) and anthocyanins). I also reviewed several of plants they from solanum species exist the antimicrobial activity due to their phenolic compounds.

Keywords: Solanaceae • Phenolic compounds • antibacterial • antimicrobial • Pharmacological activities.

Introduction

Solanum is a large genus of flowering and fruiting plants, which include food crops of high economic importance, the potato, the tomato and the eggplant and others. It also contains the nightshades, and nettles, and numerous plants cultivated for their ornamental flowers, and fruit [1,2]. Currently, new researchers that they found the new pesticides by developing from plants of Solanaceae e.g. glycoalkaloids, terpenoids, alkaloids, organic acids and alcohols, which effective for use in plant protection from pesticides (disturb the level of biological organization) [3]. The accumulation and receiving of several UV-absorbing phenolic compounds that are phenylpropanoid derivatives to play a significant role in UV-B (ultraviolet B- Radiation) screening and less insect herbivory in plants [4,5]. Solanum genus of about 2,300 species of flowering plants in the nightshade family (Solanaceae) [6]. The active principle being solanine and solamargine, which can cause convulsions and death if taken high in large doses, active principal include phenolic and flavonoids contents (Chlorogenic acid, vanillin, p-coumaric acid, caffeic acid, 4-hydroxy-3-methoxy cinnamaldehyde, ferulic acid, neochlorogenic acid) compounds that they responsible for the antimicrobial activity [7].

1. **Solanum aculeastrum:** Methanol extracts of plant of *S. aculeastrum* inhibited the growth of both the Gram-positive and Gram-negative bacteria. *Solanum aculeastrum* reported against *E. coli*, *S. aureus*, *P. aeruginosa*, *K. pneumoniae*, *S. faecalis* and *B. Subtilis*. The genus *Solanum* is known to be rich in steroidal gly-coalkaloids and sesquiterpenoids also phenolic compounds that have antibacterial and antimycotic properties. Fifty-two phenolic compounds isolated from *Solanum* are also Phenolic compounds having role of antibacterial [8,9].
2. **Solanum tomentosum:** Plant's secondary metabolites show their bio activities and different modes of action of phenolic compounds. The leaves and root extracts in acetone, methanol and water from *S. tomentosum* showed antibacterial activity. Methanolic and acetone both extracts are active against the bacteria that are both Gram positive and Gram-negative bacteria at

a concentration of 5 mg/ml. Mainly methanolic and acetone extracts inhibited the growth of *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae* and *Penicillium notatum*. They exhibits that phenolic compounds showed antimicrobial activity [10,11].

3. **Solanum trilobatum L:** *Solanum trilobatum* L. is an important medicinal plant in traditional Indian system from Solanaceae family [12]. The aqueous methanolic extract and benzene extracts were used to isolate secondary metabolites from aerial parts, leaves and other parts of *Solanum trilobatum* L. (Solanaceae) tested for antimicrobial activity by disc diffusion method due to presence of flavanols, and phenolic compounds. Authors revealed from the results, that they found that extracts from whole plant that is leaf, flowers, stem, fruits and roots revealed antimicrobial activity against Gram (+) and Gram (-) bacteria. Most important constituents are tannins, saponins, flavanoides, phenolic compounds, cardiac glycosides and carbohydrates indicates *S. trilobatum* is one of the potentials medicinal plant for therapeutic use in all traditional medicines and marketed formulation. *S. trilobatum*, is found to be effective in suppressing drug-induced toxicity in rats [13,14].
4. **Solanum incanum:** The ethanolic extract of fruit and flowers of *Solanum incanum* were used for testing of minimum inhibitory concentration and zone of inhibition against the bacteria that is gram positive and gram-negative bacteria such as *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Salmonella paratyphi*, *Vibrio cholera*. The plant exhibits various biologically active compounds which could serve as potential source of vegetable drugs in herbal medicine, contain alkaloids, tannins, steroids, saponins, as well as reducing sugars and phenolic compounds.¹⁴ *Solanum incanum* L. active against two Gram-negative (*Escherichia coli* and *Salmonella typhi*) and two Gram-positive (*Bacillus subtilis* and *Staphylococcus aureus*) bacteria for developing effective antimicrobial profile of the plant [15].
5. **S. villosum:** Isolated protein, and other constituents from mature leaves and flowers of *S. villosum* exist the presence of amino acids, phenolic compounds and essential amino acids, *Escherichia coli*, *Klebsiella pneumoniae* and *Penicillium notatum*. They exhibits that phenolic compounds showed antimicrobial activity [10,11].
6. **Solanum trilobatum L:** *Solanum trilobatum* L. is an important medicinal plant in traditional Indian system from Solanaceae family [12]. The aqueous methanolic extract and benzene extracts were used to isolate secondary metabolites from aerial parts, leaves and other parts of *Solanum trilobatum* L. (Solanaceae) tested for antimicrobial activity by disc diffusion method due to presence of flavanols,

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8. ***S. villosum***: Isolated protein, and other constituents from mature leaves and flowers of *S. villosum* exist the presence of amino acids, phenolic compounds and essential amino acids, and these are responsible for the antimicrobial activity, antiparasitic activity against the mollusca gastropoda *G. truncatula* [16] and other treatment of pathogenic conditions. Aqueous extract of ether and chloroform solvent of fresh and dried mature leaves and flowers of *S. villosum* active against the larvae of *Anopheles stephensi*, *Culex quinquefasciatus* and *Stegomyia aegypti* mosquitoes and against pathogenic bacteria and organism [17].
9. ***Solanum surattense***: Various extracts of plant such as *S. surattense* aqueous methanolic extract exhibited a significant [18] potential and alcoholic extracts from *Solanum surattense* used in medicine for the treatment and used against various infections they cause by different organisms or bacteria. The antimicrobial activity detected against *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi*, *Streptococcus* sp. *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Shigella dysenteriae* and *Vibrio cholerae* due to presence of flavones. *Solanum surattense* used in pharmaceutical industries due to its steroidal glycoalkaloidal chemical nature [19].
10. ***Solanum nigrum* (L)**: Non-polar extracts from leaves, seed and roots of *Solanum nigrum* were used by researchers to perform *in-vitro* antibacterial activity against pathogenic bacteria such as *Bacillus subtilis*, *Bacillus megaterium*, *Staphylococcus aureus*, *klebsiella pneumoniae*, *E. coli*, *Proteous vulgaris*, *Pseudomonas putrid* [20]. Based on earlier reports, among the great variety of secondary compounds found in plants, phenolics, and terpenoids represent the main antimicrobial agents. Aromatic compounds such as phenols, phenolic acids, alkaloids, lectins and its derivative e.g. flavonoids have been identified that it has antimicrobial agents [21].
11. ***Solanum xanthocarpum***: Commonly known by its name pili kateli. It is prevalent various time in systematic medicines [22]. Ethanolic and alcoholic extracts were evaluated for their zones of inhibition against all the Gram-negative bacteria and fungi. They have beneficial effects on the community by improving the health of human beings, by treating many diseases that are caused by infectious organism for many years due to their various chemical structures. For such activity, the source of phytochemicals has commonly found in leaves, barks, roots, flowers, fruits, and seeds of the plants and other parts of this plants [23].
12. ***Solanum melongena* L**: Most of such plants are known to contain large amounts of phenolic monoterpenes and other compounds with flavones, which have significant antifungal, antibacterial and antiviral properties along with possible inhibition of lipid peroxidation [24]. The fruit of *Solanum melongena* is a high valued vegetable all over the world because of its taste and rich of Vitamin B2 [25].
13. ***Solanum torvum* Swartz.**: The phenolic component of plant have antimicrobial activity, they were screened for Gram-positive bacteria, six Gram-negative bacteria, seven other clinical isolates and fungi [26]. The non-polar extract gives phenolic compounds of *Solanum torvum*, the part from fruit showed a wide spectrum of antimicrobial activity and the potential ability to exhibit the Anti-oxidant activities against human and animal clinical isolates. It is also containing phenolic compounds [27,28].
14. ***Solanum villosum***: Isolated protein from various extract identified about 10% essential amino acids out of fifteen amino acids. Proteins isolated from mature leaves and flowers of *S. villosum* have larvicidal activity and antimicrobial properties due to their phenolic compounds and others constituents [29].
15. ***Solanum dulcamara* L**: Authors reported that this plant produced a high content of a specific alkaloid that is solanine (from unripe fruits), solasodine (from flowers) and -solamarine (from roots) and whole plants too. These alkaloids were extracted from various parts of *S. dulcamara* by well-established various methods and was screened for their antimicrobial activity [30]. The fruits of *Solanum* Linnaeus are mostly used in Kenya for the treatment of cutaneous mycotic infections and other pathological conditions [31].
16. ***Solanum palinacanthum***: The flavonoid rutin and phenolic compounds 3,5-dicaffeoylquinic acid separated by using column chromatography and high-performance liquid chromatography, and identified by using mass and nuclear magnetic resonance spectrometry method. Methanol extract of *Solanum palinacanthum* and natural antimicrobial agents as alternative in therapeutics uses and to preserve food [32]. Bioactive substances of the plants mainly phenolic containing compounds, making species important functional foods, high levels of phenolic contents is against oxidative stress [33].
17. ***Solanum stramonifolium* Jacq**: Leaves, roots, and stems and stem parts of plant with methanolic extract of *Solanum stramonifolium* Jacq. (Solanaceae) were tested. The leaf extract showed the strongest antimicrobial activity inhibiting bacteria. Researchers tested various parts of this plant for various biological activities together with the phenolic compound and flavones behavior [34,35].
18. ***Solanum sisymbriifolium***: The solanum extract using hexane, benzene, chloroform, methanol, and aqueous extracts of the aerial part of *S. sisymbriifolium* screened for antibacterial and antifungal activities against microbial strains including Gram positive bacteria (*Bacillus subtilis*, *Bacillus coagulans*), Gram negative bacteria (*Escherichia coli*) and fungus (*Saccharomyces cerevisiae*). Many of these secondary metabolites possess significant biological and other medicinal properties which play an invaluable role in the drug discovery process [36,37].
19. ***Solanum melongena***: Antimicrobial activity tests were carried out using agar disc diffusion methods with ten microbial species, and with two fungi strains. The extracts showed high antibacterial activity against all the strains tested. It was observed that the plant extracts were more active against Gram-negative bacteria than against Gram-positive bacteria. Ethanol and acetone were also used as negative controls [38,39].
20. ***Solanum violaceum* Ortega**: Total phenolic and flavone content of plant were evaluated in methanolic and chloroform extract of the *Solanum violaceum* plants or other parts is positively responsible to the antimicrobial and other infections. Strains of Gram-positive (*Bacillus cereus*, *Bacillus subtilis*), three strains of Gram-negative bacteria (*Escherichia coli*, *Salmonellatyphi*, *Vibrio cholerae*), and three strains of fungi (*Microsporumcanis*, *Candida albicans*, *Aspergillus niger*) were used to evaluate the antimicrobial activity. The authors showed that phenolic compounds possess antimicrobial activity. Methanolic extract

400 µg/disc of the plant shows broad-spectrum antimicrobial activity [40,41,42].

21. ***Solanum spirale Roxb.***: All isolated compounds showed antibacterial activity with the MIC, and trans-cinnamic acid showed very good antibacterial activity against *S. aureus* with the MIC of 250 µg/mL than lupeol and this is the first report which details the identification & isolation and structure elucidation of lupeol and trans-cinnamic acid together with their anticancer, and antibacterial activities from this medicinal plant [43,44].
22. ***Solanum elaeagnifolium***: *In-vitro* antimicrobial activity was screened by using Muller Hinton Agar. The plates were prepared by pouring 15 ml of molten media into sterile petriplates. The antimicrobial activity was determined in the extracts using agar disc diffusion method; Zone of inhibition of extracts were compared with that of standards like ampicillin and chloramphenicol and griseofulvin for antifungal activity [45,46].
23. ***Physalis peruviana***: A plant species of the genus *Physalis* is the nightshade family Solanaceae, few species of *Physalis* have phenolic profiles with valuable specific chemical makers, their phenolic composition and antioxidant properties were found among the *P. ixocarpa*, *P. angulate*, *P. alkekengi* var. *franchetii* and *P. angulate* [47].
24. ***Solanum indicum* and *Solanum surattense***: These nightshade rich from phenolic compounds and occurring from family Solanaceae. The fruit extract on hydrolysis produce rich content of total phenolics (250.4-289.5 mg/g). In recent researches on these plants scientists found various other chemical constituents from extract using LC-ESI-MS/MS technique [48].
25. ***Solanum tuberosum***: Prior named by potato, it is synthesized from phenolic compounds and provides protection from various type of viruses, insects, bacteria and fungi. From the alternate theory and researches it was observed that the species of potato shows promoting effects in humans [49].
26. ***Nicotiana glauca***: It is a plant of nicotiana species from plant family Solanaceae. Methanolic extract from flowers having rich amount of phenolics compounds that is garlic acid with highest anti-inflammatory activity and antioxidant activity [50].
27. ***Solanum septemlobum***: In this plant, one of two species of boxthorn is the family Solanaceae with several phenolic compounds such as chlorogenic, *p*-coumaric and ferulic acids where isoquercitrin, rutin and quercitrin have highest value as antioxidant properties, and also inhibit the Gram-positive bacteria against *Escherichia coli* [51].
28. ***Lavandula stoechas***: The phenolic compounds of the plants determined by using high-performance liquid chromatography electrospray ionization mass spectrometry (HPLC/ESI-MS) and the aqueous extract of plant's flower shows antioxidant and anti-microbial activity [52].
29. ***Solanum lycocarpum***: Polyphenolic compounds of family Solanaceae consumed as natural components of vegetables, beans, fruits, and/or phytotherapeutics. The ethanolic extract of phenolic constituents in plant shows antioxidant, antibacterial, and cytotoxic potential. The phenolic compounds determined by using High performance liquid chromatography coupled with DAD analysis [53].
30. ***Lycium barbarum L.***: It is also known by wild fruit from large shrub of the family Solanaceae, subfamily Solanoideae, the methanolic content of the fruit shows polyphenols. In the various phytochemical analyses, it shows enhancement of the therapeutic effect. The different parts of plants such as dried fruits, juice, goji wine and goji yoghurt show antioxidant activity with minima concentrations [54,55].
31. ***Capsicum annuum***: Bell peppers (*Capsicum annuum*) belong to the Solanaceae family, common name with sweet pappers. The bioactive compounds of this plant are namely phenolic acids, and carotenoids. Green sweet pepper's methanolic extract (200 µL)

exhibited the highest antioxidant potential among tested [56,57,58].

Conclusion

Phytochemicals found in all parts of the plant from Solanaceae with high value of contents, various species of solanum contribute with namely allopathy as well as prevalent in traditional system of India. This study material provides theoretical and practical information of phenolic components that present in plant in rich quantity and determine by using various technique such as by high performance liquid, chromatography with ultraviolet detection, HPLC-UV. This review shows that the phenolic compounds are highly effective against various microorganism, bacteria, fungus, isolated organism and reduce oxidative stress. Further study gets a better insight into their components content.

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