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THE EMERGING ROLE OF *SOLANUM BETACEUM* CAV. IN HUMAN HEALTH: A COMPREHENSIVE REVIEW OF ITS PHYTOCHEMISTRY AND PHARMACOLOGICAL ACTIVITIES

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ABSTRACT

Solanum betaceum Cav. (tree tomato or tamarillo) is an underutilized fruit belonging to the family Solanaceae that has gained considerable attention because of its rich nutritional composition and diverse pharmacological properties. The fruit contains a wide range of bioactive constituents, such as polyphenols, flavonoids, carotenoids, anthocyanins, vitamins, and other bioactive compounds that contribute to its health-promoting effects. Experimental studies have demonstrated a broad spectrum of biological activities, such as antioxidant, anti-inflammatory, anticancer, antidiabetic, anti-skin-aging, antinociceptive effects, highlighting its potential as a functional food and nutraceutical. This review summarizes the phytochemical composition, and pharmacological activities of *S. betaceum*, with emphasis on the relationship between its bioactive constituents and therapeutic potential.

KEYWORDS: *Solanum betaceum*, Phytochemistry, Pharmacological activities, Antioxidant activity.

INTRODUCTION

Solanum betaceum Cav. (syn. *Cyphomandra betacea* Sendt.), commonly known as tamarillo or tree tomato, is a fruit-bearing species of the family Solanaceae native to the Andean region of South America. The fruit is widely consumed for its nutritional value and has been

traditionally used in folk medicine in several South American countries for the management of sore throat, stomach disorders, and hypercholesterolemia. In Costa Rican traditional medicine, the fresh fruit is also consumed as a remedy for influenza and liver ailments. The presence of diverse phytochemicals has made S. betaceum an important subject of research because of its potential therapeutic applications. Experimental studies have demonstrated a wide range of pharmacological activities, including antioxidant, anti-inflammatory, antidiabetic, neuroprotective, and anti-obesity effects. This review provides an overview of the phytochemical profile and pharmacological activities of S. betaceum, highlighting its therapeutic potential.[1,2]

Fig. 1: *Solanum betaceum* Cav.

PHYTOCHEMICAL PROFILE

Total polyphenols

Total polyphenols are the major bioactive compounds in *Solanum betaceum* and contribute significantly to its antioxidant potential by scavenging reactive oxygen species(ROS). In the evaluated breeding population, the total polyphenol content ranged from 5.11 to 16.59 mg gallic acid equivalents (GAE)/g dry weight, with an average of 8.47 mg GAE/g dry weight.[3,4]

Flavonoids

Flavonoids are one of the major phenolic compounds present in *Solanum betaceum* and contribute to its antioxidant, antibacterial, and antiviral activities. In the evaluated breeding

population, the total flavonoid content ranged from 1.24 to 6.70 mg catechin equivalents (CE) g^{-1} dry weight, with an average value of 2.99 mg CE g^{-1} dry weight, indicating considerable variability among the genotypes. The pulp has been reported to contain a higher flavonoid content than the peel; however, the bioflavonoids quercetin and myricetin have been detected only in the peel.[3,4]

Carotenoids

Carotenoids are important lipophilic pigments in *Solanum betaceum* that are responsible for the characteristic yellow to orange-red coloration of the fruit and contribute to its antioxidant and nutraceutical properties. The total carotenoid content in the evaluated breeding population ranged from 50.39 to 460.72 µg β-carotene g^{-1} dry weight, with an average value of 223.38 µg β-carotene g^{-1} dry weight, demonstrating considerable variation among the genotypes. β-Carotene was reported as the predominant carotenoid, although other carotenoids, including β-cryptoxanthin and lutein, as well as chlorophyll pigments, have also been identified in tree tomato.[3,4]

Anthocyanins

The red to purple coloration of *Solanum betaceum* fruits is primarily due to anthocyanins, a group of water-soluble flavonoid pigments with notable antioxidant activity. Across the studied breeding population, anthocyanin levels varied considerably, ranging between 1.06 and 240.49 mg cyanidin-3-glucoside equivalents per 100g dry weight, with a mean of 38.08 mg. Most investigations highlight the peel as the major reservoir of anthocyanins, though some reports suggest that the pulp may also contain some amounts.[3,4]

Vitamin C

Vitamin C (ascorbic acid) is one of the major antioxidant vitamins present in *Solanum betaceum* and plays an important role in protecting cells against oxidative stress by neutralizing free radicals. In the evaluated breeding population, the vitamin C content ranged from 78.29 to 428.16 mg 100 g^{-1}, with an average value of 209.80 mg 100 g^{-1}, demonstrating substantial variation among the genotypes, confirming S. betaceum as an excellent natural source of vitamin C.[3,4]

Fig. 2: Fruits of *Solanum betaceum* Cav.

PHARMACOLOGICAL ACTIVITY

Antioxidant Activity

Solanum betaceum exhibits potent antioxidant activity owing to its rich content of phenolic compounds, flavonoids, anthocyanins, carotenoids, and vitamin C. Both aqueous and 80% ethanolic fruit extracts have demonstrated significant free radical scavenging activity in 2,2-Diphenyl-1-picrylhydrazyl(DPPH),2,2′-Azino-bis(3-ethylbenzothiazoline-6-sulfonicacid).

(ABTS), Ferric Reducing Antioxidant Power (FRAP) and Oxygen Radical Absorbance Capacity (ORAC) assays, with the 80% ethanolic extract showing greater antioxidant capacity due to its higher phenolic content. Chlorogenic acid has been identified as the predominant phenolic compound, while delphinidin-3-rutinoside is the major anthocyanin. In addition, ellagic acid, rutin, catechin, epicatechin, kaempferol-3-rutinoside, and isorhamnetin-3-rutinoside have also been reported in tamarillo. The peel possesses significantly higher total phenolic content and antioxidant activity than the pulp, as demonstrated by Cupric Ion Reducing Antioxidant Capacity assay (CUPRAC), FRAP, and Folin–Ciocalteu assays. Furthermore, methanolic leaf extracts exhibit concentration-dependent DPPH and ABTS radical scavenging activity, with the red-fruit cultivar showing greater antioxidant potential than the yellow-fruit cultivar because of its higher flavonoid and terpenoid content. Collectively, these findings demonstrate that different parts of *S. betaceum* are rich sources of natural antioxidants capable of reducing oxidative stress.[5,6,7]

Anti-inflammatory Activity

The methanolic leaf extracts of *Solanum betaceum* showed notable anti-inflammatory activity through inhibition of protein denaturation and lipoxygenase (LOX) in a dose-dependent manner. The red-fruit cultivar exhibited greater inhibitory activity than the yellow-fruit cultivar, likely due to its higher levels of flavonoids and terpenoids. These findings suggest that S. betaceum leaves possess promising anti-inflammatory potential and may serve as a natural therapeutic agent for the management of inflammatory disorders.[7]

Antidiabetic Activity

Solanum betaceum leaves exhibit significant antidiabetic activity due to their high content of hydroxycinnamic acids, particularly rosmarinic, chlorogenic, and caffeic acids. The aqueous extract selectively inhibited α-glucosidase (IC_{50} = 1.617 mg/mL), delaying carbohydrate digestion and controlling postprandial blood glucose, while showing no effect on α-amylase, reducing the risk of gastrointestinal side effects. It also strongly inhibited aldose reductase (IC_{50} = 0.236 mg/mL), a key enzyme in the polyol pathway, thereby helping prevent diabetes-related complications. These findings highlight *S. betaceum* leaves as a promising natural source of bioactive compounds for diabetes management.[8]

Anticancer Activity

Solanum betaceum has demonstrated promising anticancer activity *in vitro*, particularly against prostate cancer cell lines (DU-145 and PC-3). Fruit extracts significantly reduced cell viability, induced apoptosis, and caused G2/M phase cell cycle arrest, with the 80% ethanolic extract exhibiting greater antiproliferative activity than the aqueous extract. The observed effects are largely attributed to the fruit's phenolic compounds and other bioactive phytochemicals, highlighting its potential as a source of natural anticancer agents. Similarly, the methanolic seed extract of red *Solanum betaceum* fruit demonstrated significant anticancer activity against Ca9-22 gingival carcinoma cells. The extract reduced cell viability, inhibited cell migration and colony formation, and induced apoptosis in a dose-dependent manner, demonstrating potent cytotoxic and antiproliferative properties. These findings highlight the therapeutic potential of S. betaceum seed extracts as a promising natural source of anticancer agents, although further *in vivo* and clinical studies are needed to validate these effects.[9,10]

Anti-skin Aging Activity

Solanum betaceum fruit extracts exhibit promising anti-skin aging activity by inhibiting key enzymes involved in skin aging, including tyrosinase, elastase, and hyaluronidase. Among the tested extracts, the methanolic extract of red fruit seeds showed the strongest tyrosinase inhibition (50.4%), while the ethanolic extract of yellow fruit pulp and the methanolic extract of yellow fruit seeds demonstrated the highest elastase (28.1%) and hyaluronidase (20.2%) inhibitory activities, respectively. These findings suggest that S. betaceum may serve as a promising natural ingredient for cosmetic and dermatological applications aimed at delaying skin aging.[10]

Prebiotic Activity

Solanum betaceum hydrocolloids exhibited promising prebiotic activity by resisting gastrointestinal digestion and serving as fermentable substrates for gut microbiota. The hydrocolloids significantly promoted the growth of beneficial *Bifidobacterium a*nd *Lactobacillus* species while reducing the proliferation of pathogenic bacteria such as *Escherichia coli* and *Bacteroides*. Furthermore, fermentation of the hydrocolloids enhanced the production of short-chain fatty acids, particularly acetate, propionate, and butyrate, indicating their potential to improve gut health and support intestinal homeostasis.[11]

Antinociceptive activity

The galactoarabinoglucuronoxylan isolated from *Solanum betaceum* pulp demonstrated potent antinociceptive activity by significantly reducing acetic acid-induced abdominal constrictions and inhibiting inflammatory pain in the formalin-induced nociception model. The polysaccharide exhibited dose-dependent analgesic effects, indicating its potential as a natural pain-relieving agent. The antinociceptive activity was primarily associated with the suppression of inflammatory mediators rather than direct inhibition of neurogenic pain.[12]

Anti-anemic Activity

Solanum betaceum juice demonstrated significant anti-anemic activity by increasing hemoglobin levels in pregnant women with anemia when administered as an adjunct to iron supplementation. After two weeks of treatment, the intervention group showed a greater increase in hemoglobin levels (1.75 g/dL) compared to the control group receiving iron supplements alone (0.89 g/dL). This effect was attributed to the fruit's rich iron and vitamin C content, which enhance iron absorption and promote hemoglobin synthesis, highlighting its potential as a natural dietary adjunct in anemia management.[13]

CONCLUSION

Solanum betaceum Cav. is an underutilized fruit with remarkable nutritional value and a rich phytochemical profile, including polyphenols, flavonoids, carotenoids, anthocyanins, and vitamins, which contribute to its diverse pharmacological activities. The available evidence demonstrates its antioxidant, anti-inflammatory, antidiabetic, anticancer, anti-skin-aging, prebiotic, antinociceptive, and anti-anemic potential, highlighting its importance as a functional food and a promising source of natural therapeutic agents. Although current findings are encouraging, additional experimental and clinical investigations are essential to establish its safety, efficacy, and future therapeutic use.

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