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Anti-Diabetic And Antioxidant Activity Of *Swertia Chirayita*: An In Vitro Study

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Abstract

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia and associated oxidative stress, leading to severe long-term complications. Medicinal plants have gained significant attention as alternative therapeutic agents due to their safety, affordability, and bioactive potential. The present study investigates the phytochemical composition, antioxidant activity, and in vitro anti-diabetic potential of *Swertia chirayita*, a traditional medicinal herb widely used in Ayurvedic medicine. Methanolic extracts of the whole plant were subjected to qualitative phytochemical screening, DPPH free radical scavenging assay, and α-amylase inhibition assay. The extract demonstrated the presence of alkaloids, flavonoids, tannins, saponins, terpenoids, and carbohydrates. Significant antioxidant activity was observed that was comparable to that of ascorbic acid. The extract also exhibited strong α-amylase inhibitory activity, indicating potential anti-diabetic properties. These findings support the traditional use of *Swertia chirayita* and highlight its potential as a source of natural antioxidant and anti-diabetic agents.

Keywords: Diabetes mellitus, *Swertia chirayita*, Antioxidant activity, α-amylase inhibition, Phytochemicals.

1. Introduction

Diabetes mellitus (DM) is a major global health concern, particularly in low- and middle-income countries, where its prevalence is rising rapidly. It is a metabolic disorder characterized by impaired insulin secretion, insulin action, or both, resulting in chronic hyperglycemia and disturbances in carbohydrate, lipid, and protein metabolism (DeFronzo, 2004). Long-term complications of diabetes include cardiovascular disease, nephropathy, neuropathy and retinopathy (Velho and Froguel, 1997).

Oxidative stress plays a critical role in the pathogenesis of diabetes and its complications. Excess generation of free radicals leads to cellular damage, emphasizing the need for antioxidant-based therapeutic strategies (Krishnaiah et al., 2011). Although synthetic anti-diabetic drugs such as acarbose and metformin are effective, their use is often associated with adverse gastrointestinal effects, prompting interest in plant-based alternatives (Yilmazer-Musa et al., 2012).

Swertia chirayita (family: *Gentianaceae*), commonly known as Chiretta, is a medicinal herb traditionally used for the treatment of diabetes, liver disorders, fever and digestive ailments. The plant is rich in bitter secoiridoid glycosides and other bioactive compounds known for their pharmacological properties (Scartezzini and Speroni, 2000; Chen et al., 2011). Several studies have reported its antibacterial, anti-inflammatory, antioxidant, and antidiabetic activities (Bhatt et al., 2006; Arya et al., 2011). Recent studies have further confirmed the pharmacological relevance of *S. chirayita*, showing significant antioxidant and antidiabetic potential through biochemical assays and nanosuspension formulations (Lubna Sartaj et al., 2023; Febriyanti et al., 2025). Medicinal plant extracts with high phenolic and flavonoid contents are increasingly validated as sources of dual antioxidant and carbohydrate‑digesting enzyme inhibition, supporting their use in diabetes management (Discover Plants, 2025). Contemporary reviews emphasize that *S. chirayita* contains over 100 bioactive metabolites, including flavonoids and secoiridoids, which contribute to its broad pharmacological effects but require further mechanistic study.

The present study aims to scientifically evaluate the phytochemical composition, antioxidant activity, and in vitro anti-diabetic potential of *S. chirayita*.

2. Materials and Methods

2.1 Plant Material and Extraction

The dried whole plant of *S. chirayita* was procured from a local herbal supplier and authenticated using standard taxonomic keys. The plant material was shade-dried, powdered, and extracted with methanol by maceration for 72 h. The extract was filtered and concentrated under reduced pressure following standard procedures (Harborne, 1998). The extraction methodology followed standard phytochemical procedures as described by Harborne (1998) and Sofowora (2008).

2.2 Phytochemical Screening

Preliminary phytochemical screening of the methanolic extract was performed to detect the presence of alkaloids, flavonoids, tannins, saponins, and phenolic compounds using standard qualitative tests (Trease and Evans, 2002).

2.3 DPPH Radical Scavenging Assay

The antioxidant activity was assessed using the DPPH free radical scavenging assay as described by Brand-Williams et al. (1995). Various concentrations of the extract were mixed with DPPH solution and absorbance was measured at 517 nm. Ascorbic acid was used as the reference standard.

2.4 α-Amylase Inhibition Assay

The α-amylase inhibitory activity was determined using the colorimetric method described by Bernfeld (1955) and De Sales et al. (2012). The reaction mixture containing enzyme, extract, and starch substrate was incubated and absorbance was measured at 540 nm.

3. Results

3.1 Phytochemical Screening

Qualitative phytochemical analysis of the methanolic extract of *S. chirayita* revealed the presence of several bioactive constituents, including alkaloids, flavonoids, tannins, saponins, terpenoids, and carbohydrates (Table 1). The diversity of phytochemicals detected supports the medicinal relevance of the plant.

3.2 Antioxidant Activity (DPPH Assay)

The antioxidant potential of the methanolic extract was evaluated using the DPPH free radical scavenging assay. The methanolic extract of *S. chirayita* exhibited concentration-dependent DPPH radical scavenging activity (Table 2). At higher concentrations, the extract showed substantial inhibition of DPPH radicals, indicating strong antioxidant potential. A comparative analysis with ascorbic acid showed lower but significant antioxidant potential (Figure.1).

Table 1. Qualitative phytochemical constituents of *S. chirayita*.

Phytochemicals	Test Applied	Result
Alkaloids	Mayer's test	+
Carbohydrates	Molisch's test	+
Flavonoids	Alkaline test	+
Terpeonoids	Salkowski's test	+
Saponins	Foam test	+
Tannins	Ferric Chloride Test	+

Table 2. Representative DPPH radical scavenging activity of *S. chirayita*.

Concentration (µg/mL)	% Inhibition
25	51
50	63
100	75
200	90

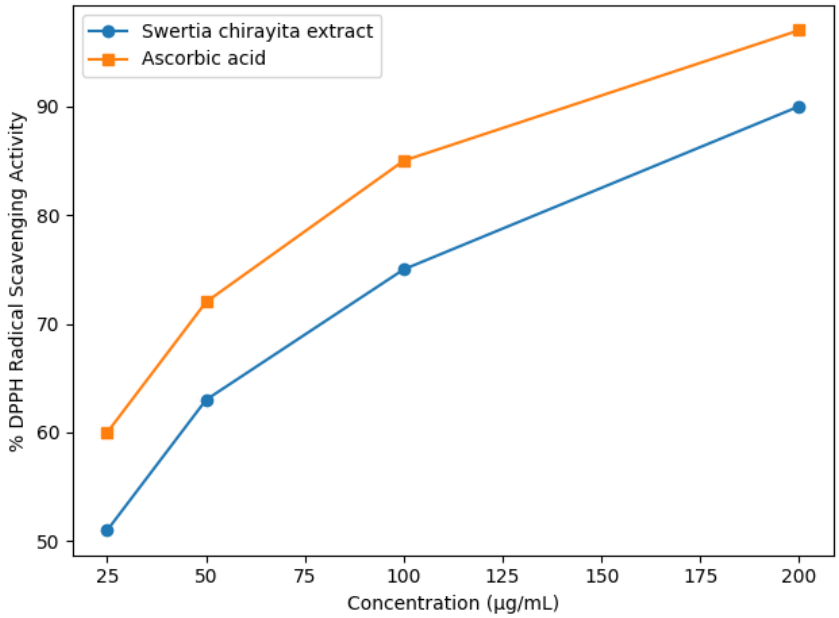

Figure 1. Comparative DPPH radical scavenging activity of methanolic extract of S. *chirayita* and standard ascorbic acid at different concentrations.

3.3 Anti-diabetic Activity (α-Amylase Inhibition Assay)

The anti-diabetic potential of *S. chirayita* extract was assessed by evaluating its ability to inhibit α-amylase activity. The extract demonstrated concentration-dependent inhibition of α-amylase. Acarbose showed higher inhibitory activity at lower concentrations (Table 3 and Figure 2).

Table 3. Representative α-amylase inhibitory activity of *S. chirayita*.

Concentration (µg/mL)	% Inhibition
0.1	22
0.5	41
1.0	58
5.0	76

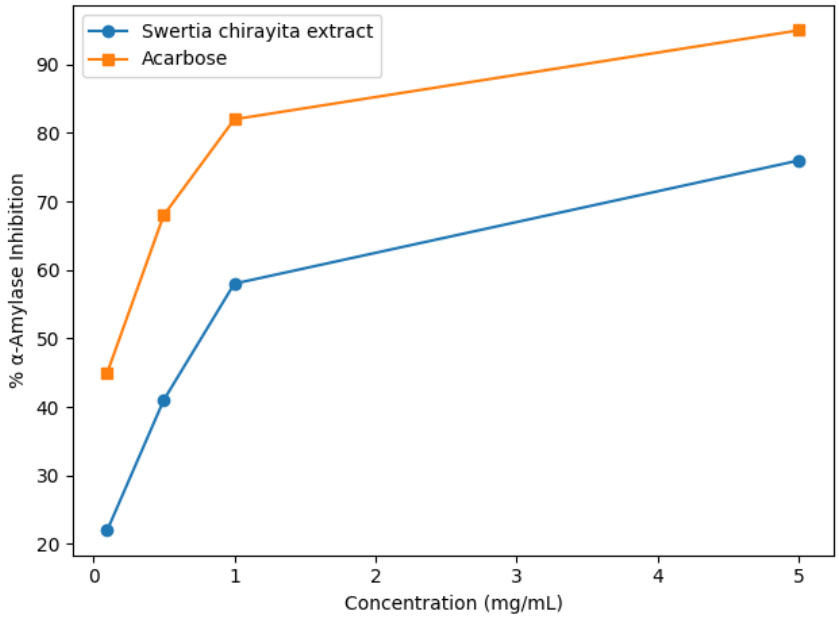

Figure 2. Representative α-amylase inhibitory activity of methanolic extract of *S. chirayita* demonstrating concentration-dependent enzyme inhibition.

4. Discussion

The presence of diverse phytochemicals such as flavonoids, tannins, alkaloids, and phenolic compounds in *S. chirayita* may contribute significantly to its observed antioxidant and anti-diabetic activities. Phenolic compounds and flavonoids are well known for their ability to donate hydrogen atoms or electrons and neutralize free radicals, thereby reducing oxidative stress (Ali Asgar, 2013; Li et al., 2011).The strong DPPH radical scavenging activity observed in the methanolic extract suggests its effectiveness as a natural antioxidant. Similar antioxidant potential of medicinal plants rich in polyphenols has been reported previously (Krishnaiah et al., 2011; Gulati et al., 2012).

The α-amylase inhibitory activity exhibited by the extract indicates its potential role in controlling postprandial hyperglycemia by delaying carbohydrate digestion. Inhibition of α-amylase is a recognized therapeutic approach in diabetes management, as reported for several plant-derived inhibitors (Kandra, 2003; De Sales et al., 2012). The observed activity of *S. chirayita* is consistent with earlier reports highlighting the anti-diabetic efficacy of traditional medicinal plants (Marles and Farnsworth, 1995; Mentreddy, 2007). The presence of bioactive phytochemicals such as flavonoids, tannins, and phenolic compounds appears to play a key role in these pharmacological effects (Marles and Farnsworth, 1995; Funke and Melzig, 2006).

Recent in vitro studies on medicinal plants used traditionally for diabetes have reported strong α-amylase and α-glucosidase inhibition concomitant with antioxidant activity, supporting our findings on plant-derived enzyme inhibition (Lubna Sartaj et al., 2023; Febriyanti et al., 2025). Comparative phytochemical studies demonstrate that phenolic and flavonoid content often correlates with antioxidant and antidiabetic activities in plant extracts, highlighting the mechanistic potential of bioactive compounds present in *S. chirayita* extract (Discover Plants, 2025). In addition, nanoscale formulations of *S. chirayita* have been explored to enhance bioavailability and therapeutic efficacy, marking a promising direction for future antidiabetic interventions (Manjunatha et al., 2023).

Overall, the combined antioxidant and enzyme inhibitory activities of *S. chirayita* support its traditional use in diabetes management and suggest that its bioactive compounds may act synergistically to exert therapeutic effects.

5. Conclusion

The findings of the present study demonstrate that *S. chirayita* possesses significant antioxidant and in vitro anti-diabetic activities, supporting its traditional medicinal use. The plant may serve as a promising source of natural bioactive compounds for the development of safer anti-diabetic therapeutics. Further in vivo studies and isolation of active constituents are recommended to validate its clinical potential.

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