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Research

Antidiabetic Potential of *Abutilon Crispum* Stem: In Vitro Enzyme Inhibition Study Targeting Postprandial Hyperglycemia

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	Abstract
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2025 All rights reserved.  Creative Commons Attribution 4.0 International License.	Diabetes mellitus, particularly type 2 diabetes, is a chronic metabolic disorder marked by persistent hyperglycemia and associated complications. Although several synthetic drugs are available for its management, they often produce undesirable side effects. This has led to an increased interest in traditional medicinal plants as alternative therapeutic agents. <i>Abutilon crispum</i>, a plant used in traditional medicine for various ailments, remains largely unexplored for its antidiabetic potential. The present study aimed to evaluate the inhibitory activity of the ethanol extract of <i>Abutilon crispum</i> stem against two key carbohydrate-hydrolyzing enzymes, α-amylase and α-glucosidase, to assess its potential in managing postprandial hyperglycemia. The ethanol extract was tested in vitro at concentrations ranging from 100–500 μg/mL for its ability to inhibit α-amylase and α-glucosidase activities, using Acarbose as a standard. The percentage inhibition and IC₅₀ values were calculated to determine efficacy. The extract exhibited dose-dependent inhibitory effects against both enzymes. Maximum inhibition for α-amylase and α-glucosidase was $59.09 \pm 2.27\%$ and $48.57 \pm 2.05\%$ at 500 μg/mL, with corresponding IC₅₀ values of 415.36 μg/mL and 520.11 μg/mL. Although less potent than Acarbose, the extract's moderate activity indicates the presence of bioactive compounds such as flavonoids and phenolics. This study provides the first evidence of α-amylase and α-glucosidase inhibition by <i>A. crispum</i> stem extract, supporting its traditional use and potential as a natural antidiabetic agent. Further phytochemical and in vivo investigations are warranted. Keywords: <i>Abutilon crispum</i>, α-amylase, α-glucosidase, antidiabetic, enzyme inhibition, medicinal plants.

1. INTRODUCTION

Diabetes mellitus (DM) is a chronic endocrine disorder characterized by elevated blood glucose levels due to either insufficient insulin production (Type 1 diabetes) or impaired insulin action and secretion (Type 2 diabetes). Among the two, Type 2 diabetes mellitus (T2DM) accounts for over 90% of all diabetes cases and is often associated with obesity, insulin resistance, and metabolic syndrome [1]. Currently, several pharmacological interventions are available for the management of diabetes, including insulin therapy and oral hypoglycemic agents such as biguanides (e.g., metformin), sulfonylureas, thiazolidinediones, DPP-4 inhibitors, SGLT2 inhibitors, and α -glucosidase inhibitors (e.g., Acarbose) [2]. While these drugs are effective to varying degrees, their prolonged use is often associated with undesirable side effects, including gastrointestinal disturbances, weight gain, liver toxicity, hypoglycemia, and reduced efficacy over time due to drug resistance [3]. In addition, the high cost of synthetic medications places a financial burden on patients in low- and middle-income countries. These limitations have led to increased interest in alternative and complementary therapies derived from natural sources, particularly traditional medicinal plants.

Traditional medicinal systems, such as Ayurveda, Traditional Chinese Medicine (TCM), Siddha, and Unani, have long utilized a variety of plant species for the treatment of diabetes and related metabolic disorders [4]. These systems are rich repositories of ethnobotanical knowledge, which have been passed down through generations. Medicinal plants are known to be sources of diverse bioactive compounds, including alkaloids, flavonoids, glycosides, terpenoids, saponins, phenolic acids, and tannins [5]. A large number of medicinal plants have been scientifically validated for their antidiabetic potential through in vitro and in vivo studies. For instance, *Momordica charantia* (bitter melon) contains charantin, vicine, and polypeptide-p bioactive compounds that exhibit insulin-like activity [6]. *Gymnema sylvestre*, commonly referred to as “gurmar” or the sugar destroyer, contains gymnemic acids known to suppress sweet taste perception and inhibit intestinal glucose absorption [7]. *Trigonella foenum-graecum* (fenugreek) is rich in soluble fiber and 4-hydroxyisoleucine, which enhance insulin secretion and improve insulin sensitivity [8]. *Tinospora cordifolia* demonstrates antidiabetic activity through the modulation of insulin signaling pathways and regeneration of pancreatic β -cells [9]. Similarly, *Ocimum sanctum* (holy basil) has been reported to reduce both fasting and postprandial blood glucose levels in diabetic models [10]. Other plants such as *Pterocarpus marsupium*, *Syzygium cumini*, *Ficus racemosa*, and *Aegle marmelos* have also been extensively studied and shown to possess significant hypoglycemic effects [11]. Collectively, these studies affirm the therapeutic potential of medicinal plants and provide a strong scientific rationale for their integration into modern diabetes management strategies as effective and safer alternatives to synthetic drugs.

Despite this growing body of research, several traditionally used plants remain underexplored for their antidiabetic activity. One such plant is *Abutilon crispum*, a member of the Malvaceae family, which is distributed in parts of India, Sri Lanka, and Africa. It has been used in folk medicine for its anti-inflammatory, analgesic, and wound-healing properties [12]. Ethnobotanical reports suggest its use in managing fever, infections, and pain-related conditions [13]. However, a comprehensive pharmacological evaluation of *A. crispum*, particularly for antidiabetic activity, is lacking. Unlike other species in the genus *Abutilon*, which have received attention for their bioactive potential, *A. crispum* remains largely overlooked in scientific literature, and no studies to date have reported its effect on key diabetic targets such as α -amylase and α -glucosidase.

In this context, the present study aims to evaluate the α -amylase and α -glucosidase inhibitory activity of the ethanol extract of *Abutilon crispum* stem. This investigation represents the first scientific attempt to assess the antidiabetic potential of this traditionally used but under-researched plant. The study compares the enzyme inhibitory activity of the extract with that of Acarbose, a standard drug, to establish a preliminary understanding of its efficacy. By exploring this plant's activity against key carbohydrate-digesting enzymes, the study seeks to contribute to the development of plant-based interventions for diabetes management and to validate the ethnopharmacological relevance of *A. crispum* in metabolic disorders.

2. MATERIALS AND METHODS

2.1. Collection, authentication, and preparation of extract

The fresh stems of *Abutilon crispum* were collected from their natural habitat, ensuring they were free from disease or damage. The plant material was authenticated by a Dr. P Radha, Research Office (Botany), Sci II i/c, Siddha Medicinal Plants Garden, CCRS, Ministry of Ayush, Tamilnadu, and a voucher specimen was deposited for future reference (A260325272C). The collected stems were washed to remove dust and shade-dried at room temperature (25–30°C) for 10–15 days. Once dried, the stems were cut into small pieces and ground into a coarse powder using a mechanical grinder, then sieved through a 40-mesh sieve. For extraction, 100 g of the powdered stem was soaked in 1 L of ethanol in a sealed glass container and left to macerate at room temperature for 72 hours with intermittent shaking. The extract was then filtered using Whatman No. 1 filter paper, and the filtrate was concentrated under reduced pressure using a rotary evaporator at 40–50°C. The resulting semi-solid extract (EEAC) was further dried in a vacuum desiccator and stored in an air-tight container at 4°C for future use.

The percentage yield of the extract was calculated based on the initial weight of the plant material and the final weight of the dried extract [14].

2.2. In-vitro anti-diabetic activity

2.2.1. In-vitro α -amylase inhibition assay

The α -amylase assay of the extract followed a standard procedure with minor adjustments. In a 96-well plate, a reaction mixture was prepared, consisting of 50 μ L of phosphate buffer (100 mM, pH = 6.8), 10 μ L α -amylase (2 U/mL), 20 μ L of EEAC at varying concentrations (100, 200, 300, 400, 500 μ g/mL), and a standard. After a 20-minute incubation at 37 °C, 10 μ L of 1% soluble starch was added, followed by another 30-minute incubation. Subsequently, 100 μ L of color reagent DNS was added and the mixture was boiled at 95 °C for 15 minutes. The change in color was measured at a wavelength of 540 nm using a multi-plate reader. The results represent the average of three independent experiments and were calculated as percentage inhibition according to the following formula [15].

$$\text{Percentage inhibition (\%)} = \frac{\text{Absorbance control} - \text{Absorbance test}}{\text{Absorbance control}} \times 100$$

2.2.2. In-vitro α -glucosidase inhibition assay

The α -glucosidase assay of the extract was conducted following the standard protocol with minor adjustments. In a 96-well plate, 50 μ L of phosphate buffer (100 mM, pH = 6.8), 10 μ L of α -glucosidase (1 U/mL), 20 μ L of EEAC, and varying concentrations of the standard (acarbose) ranging from 100 to 500 μ g/mL were incubated for 15 minutes at 37 °C. Subsequently, 20 μ L of 5 mM substrate (4-nitrophenyl β -D-glucopyranoside) was added to each well and allowed to incubate for an additional 20 minutes at 37 °C. The reaction was halted by adding 50 μ L of 0.1 M sodium carbonate to each well. The absorbance corresponding to the release of p-nitrophenol, indicative of enzyme activity, was measured at 405 nm using a multiplate reader. The results, representing the mean of three independent experiments, were expressed as percentage inhibition, calculated using the following formula [15].

$$\text{Percentage inhibition (\%)} = \frac{\text{Absorbance control} - \text{Absorbance test}}{\text{Absorbance control}} \times 100$$

3. RESULTS

3.1 In-vitro α -Amylase Inhibition Assay

The α -amylase inhibitory activity of the ethanol extract of *Abutilon crispum* stem was evaluated and compared with Acarbose, a standard α -amylase inhibitor. The results, presented in Table 1, demonstrate a clear and progressive increase in enzyme inhibition with rising concentrations of the extract.

At 100 μ g/mL, the ethanol extract exhibited 18.17% inhibition, indicating early and meaningful bioactivity. As the concentration increased, the inhibitory effect strengthened significantly, reaching 59.09% inhibition at 500 μ g/mL a more than threefold increase from the lowest concentration. This consistent upward trend confirms the extract's concentration-dependent efficacy, a desirable trait for pharmacological applications. The findings highlight the extract's promising potential as a natural antidiabetic agent.

Table 1: In-vitro α -amylase inhibition assay

Concentration (μ g/mL)	Ethanol extract (% Inhibition)	Acarbose (% Inhibition)
100	18.17 $\pm$ 1.21	49.61 $\pm$ 1.95
200	25.62 $\pm$ 1.57	60.83 $\pm$ 1.44
300	36.19 $\pm$ 2.19	74.44 $\pm$ 1.12
400	48.37 $\pm$ 2.74	85.28 $\pm$ 1.95
500	59.09 $\pm$ 2.27	93.62 $\pm$ 2.68

Mean $\pm$ SD, n=3

Acarbose, a clinically established α -amylase inhibitor, showed higher inhibition across all tested concentrations (ranging from 49.61% to 93.62%). However, the ethanol extract's performance remains noteworthy, especially considering its natural origin and plant-based composition. At 500 μ g/mL, the extract achieved over 63% of Acarbose's inhibition, underscoring its competitive bioactivity and relevance in the development of alternative therapeutic strategies.

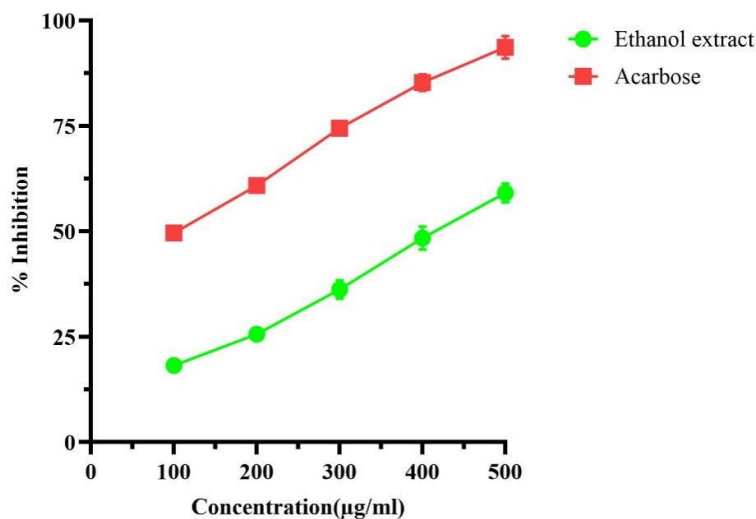


Fig 1: In-vitro α -amylase inhibition assay

The IC_{50} value the concentration required to inhibit 50% of α -amylase activity was calculated to be 415.36 $\mu\text{g/mL}$ for the ethanol extract of *Abutilon crispum*. This value reflects the extract's strong enzyme-suppressing capability and serves as a robust benchmark for comparing its efficacy with other natural and synthetic inhibitors. Such potency is particularly valuable in formulations aimed at achieving sustained and reliable inhibition of carbohydrate-digesting enzymes, which is essential for managing postprandial blood glucose levels in diabetic care.

3.2. In-vitro α -Glucosidase Inhibition Assay

The α -glucosidase inhibitory activity of the ethanol extract of *Abutilon crispum* stem was evaluated and compared with Acarbose, a clinically approved antidiabetic drug. The results, summarized in Table 2, revealed a clear and consistent dose-dependent inhibition of the enzyme by the extract.

At 100 $\mu\text{g/mL}$, the extract exhibited $13.11 \pm 0.85\%$ inhibition, indicating initial bioactivity. As the concentration increased, the inhibitory effect strengthened progressively, reaching $48.57 \pm 2.05\%$ inhibition at 500 $\mu\text{g/mL}$. This steady upward trend confirms the extract's concentration-dependent efficacy, a key indicator of its therapeutic potential. The findings highlight the extract's promising role as a natural α -glucosidase inhibitor, capable of modulating carbohydrate digestion and glucose absorption.

Table 2: In-vitro α -glucosidase inhibition assay

Concentration ($\mu\text{g/mL}$)	Ethanol extract (% Inhibition)	Acarbose (% Inhibition)
100	13.11 $\pm$ 0.85	48.18 $\pm$ 1.64
200	20.43 $\pm$ 1.17	62.24 $\pm$ 1.10
300	28.75 $\pm$ 1.54	76.49 $\pm$ 2.34
400	36.09 $\pm$ 1.36	87.38 $\pm$ 2.95
500	48.57 $\pm$ 2.05	95.94 $\pm$ 2.46

Mean $\pm$ SD, n=3

In comparison, Acarbose demonstrated higher inhibition across all tested concentrations, ranging from $48.18 \pm 1.64\%$ to $95.94 \pm 2.46\%$, with an IC_{50} value of 114.49 $\mu\text{g/mL}$. Despite this, the ethanol extract's performance remains noteworthy, especially considering its plant-based origin and potential for reduced side effects. At 500 $\mu\text{g/mL}$, the extract achieved over 50% of Acarbose's inhibition, underscoring its bioactive strength and relevance in natural antidiabetic research.

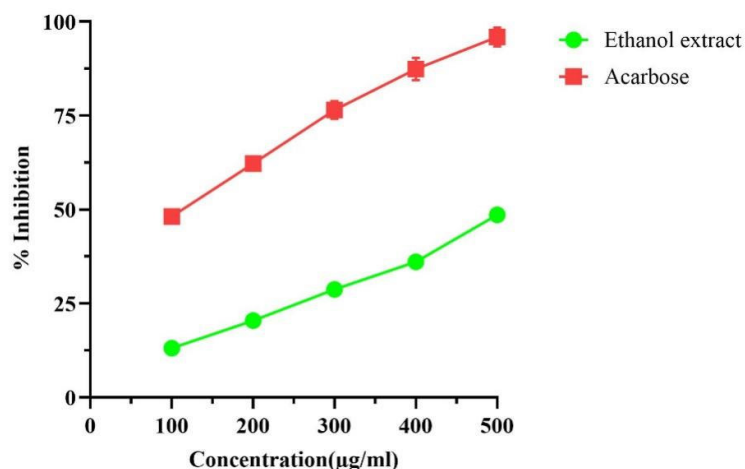


Fig 2: In-vitro α -glucosidase inhibition assay

The IC_{50} value for the ethanol extract of *Abutilon crispum* was calculated to be 520.11 $\mu\text{g/mL}$, reflecting its effective enzyme-inhibiting capability. While higher than that of Acarbose, this value still signifies substantial bioactivity, especially for a crude plant extract. Such potency is valuable in the development of herbal formulations or functional foods aimed at achieving sustained control of postprandial hyperglycemia.

The observed inhibitory action may be attributed to the presence of flavonoids, phenolics, and other phytochemicals commonly found in *Abutilon* species. These compounds are known to interact with key enzymes involved in glucose metabolism, possibly by binding to the active site of α -glucosidase or altering its conformation, thereby reducing its catalytic efficiency.

4. DISCUSSIONS

The ethanol extract of *Abutilon crispum* stem demonstrated significant inhibitory effects on the carbohydrate-digesting enzymes α -amylase and α -glucosidase, both of which play pivotal roles in postprandial glucose regulation. Inhibition of these enzymes is a well-established therapeutic strategy for managing type 2 diabetes, as it slows the breakdown and absorption of dietary carbohydrates, thereby reducing post-meal blood glucose spikes [16].

In vitro assays revealed that the extract exhibited a concentration-dependent inhibition of both enzymes. At 500 $\mu\text{g/mL}$, α -amylase activity was suppressed by $59.09 \pm 2.27\%$, while α -glucosidase inhibition reached $48.57 \pm 2.05\%$. The corresponding IC_{50} values were 415.36 $\mu\text{g/mL}$ and 520.11 $\mu\text{g/mL}$, respectively. Although Acarbose, a synthetic standard, showed higher potency (IC_{50} of 104.89 $\mu\text{g/mL}$ for α -amylase and 114.49 $\mu\text{g/mL}$ for α -glucosidase), the extract's ability to achieve over 63% of Acarbose's α -amylase inhibition and nearly 51% of its α -glucosidase inhibition at the highest concentration is pharmacologically relevant. These findings underscore the extract's potential as a natural enzyme inhibitor capable of modulating glucose metabolism.

The dual inhibition profile observed targeting both α -amylase and α -glucosidase enhances the therapeutic value of *Abutilon crispum*. Notably, previous studies suggest that a balanced inhibition pattern, particularly one that avoids excessive α -amylase suppression, is preferable to minimize gastrointestinal side effects such as bloating and flatulence [19]. The activity range of *Abutilon crispum* aligns with other traditionally used antidiabetic plants; for instance, *Syzygiumcumini* extracts have shown α -amylase IC_{50} values between 200–500 $\mu\text{g/mL}$ [20], placing *Abutilon crispum* within a comparable efficacy window.

The enzyme-inhibiting properties of the extract are likely attributed to its phytochemical composition. Preliminary screening and literature on the *Abutilon* genus indicate the presence of flavonoids, phenolic acids, alkaloids, tannins, saponins, and glycosides in the stem of *Abutilon crispum* [17]. Flavonoids and phenolic compounds are known to inhibit α -amylase and α -glucosidase by interacting with their active or allosteric sites through hydrogen bonding and hydrophobic interactions, thereby reducing catalytic efficiency [18]. Tannins, on the other hand, may form complexes with enzymes, physically obstructing their activity.

While specific antidiabetic evaluations of *Abutilon crispum* remain limited, its close relatives such as *Abutilon indicum* and *Abutilon theophrasti*—have demonstrated promising hypoglycemic effects in vivo, often linked to antioxidant activity and pancreatic β -cell protection [21]. The presence of bioactive compounds like quercetin, kaempferol, and luteolin in these species [22] supports the hypothesis that similar constituents

in *Abutilon crispum* contribute to its enzyme inhibition. A prior study on *A. indicum* leaf extract also reported strong α -glucosidase inhibition [23], reinforcing the genus's potential as a source of antidiabetic agents.

In conclusion, the ethanol extract of *Abutilon crispum* stem exhibits enzyme-inhibiting activity that is both biologically meaningful and therapeutically promising. Its efficacy, even in crude form, highlights its potential for further development into herbal formulations or as a foundation for isolating active compounds.

CONCLUSION

The ethanol extract of *Abutilon crispum* stem demonstrated meaningful inhibitory activity against both α -amylase and α -glucosidase enzymes, indicating its potential to modulate postprandial glucose levels—a critical factor in managing type 2 diabetes. Although its potency was lower than that of the synthetic standard Acarbose, the extract's ability to inhibit both enzymes in a dose-dependent manner highlights its therapeutic relevance, especially as a natural alternative.

The dual enzyme inhibition, combined with the presence of bioactive phytochemicals such as flavonoids, phenolic acids, and tannins, supports the extract's role in glucose regulation. Furthermore, its alignment with the activity profiles of other antidiabetic plants and its taxonomic proximity to well-studied *Abutilon* species reinforce its potential as a candidate for herbal drug development.

These findings provide a scientific basis for the traditional use of *Abutilon crispum* in diabetes management and warrant further investigation through in vivo studies and compound isolation to fully explore its pharmacological applications.

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