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Research Article

Phytochemical Evaluation and In-Vitro Alpha Amylase Inhibitory Antidiabetic Activity of *Solanum lycopersicum* Plant Extract

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ABSTRACT

The present study investigates the phytochemical profiling and in-vitro biological evaluation of plant-derived extracts with a focus on their therapeutic potential against metabolic disorders. The plant material was subjected to solvent-based extraction, followed by systematic phytochemical screening to identify major bioactive constituents, including alkaloids, flavonoids, tannins, saponins, and phenolic compounds. Quantitative estimation of total phenolic and flavonoid content was performed to correlate phytoconstituent abundance with biological activity. The in-vitro antidiabetic potential of the extract was assessed using the alpha-amylase inhibitory assay, a well-established model for evaluating postprandial glucose regulation. The extract demonstrated significant, concentration-dependent inhibition of alpha-amylase enzyme activity, indicating its potential to modulate carbohydrate metabolism and reduce glucose absorption. The observed bioactivity is attributed to the synergistic effects of polyphenolic compounds, which are known to interfere with enzyme-substrate interactions. Furthermore, critical extraction parameters were optimized to enhance yield and preserve phytochemical integrity. The study emphasizes the reproducibility and reliability of analytical methods employed for extract standardization. The findings substantiate the potential of plant-based bioactives as cost-effective, safer alternatives to conventional synthetic therapeutics in the management of diabetes mellitus. In conclusion, this work provides a scientific foundation for further isolation, structural elucidation, and mechanistic studies of active compounds, along with in-vivo validation and clinical translation. Such investigations could facilitate the development of novel phytopharmaceutical formulations with improved efficacy and safety profiles.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) represents a major global public health challenge,

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characterized by chronic hyperglycemia resulting from insulin resistance and/or impaired insulin secretion. According to recent epidemiological reports, the global prevalence of diabetes continues to rise at an alarming rate, with projections indicating a substantial increase in disease burden by 2030 and beyond (Kashtoh and Baek 2023a). The long-term complications associated with T2DM, including cardiovascular disorders, nephropathy, neuropathy, and retinopathy, significantly contribute to morbidity, mortality, and healthcare costs worldwide (ElShamey et al. 2025). One of the key therapeutic strategies in the management of postprandial hyperglycemia involves the inhibition of carbohydrate-hydrolyzing enzymes, particularly α -amylase. This enzyme plays a crucial role in the digestive process by catalyzing the breakdown of complex polysaccharides into simpler sugars, thereby facilitating glucose absorption in the bloodstream (Jafari et al. 2025). Inhibition of α -amylase delays carbohydrate digestion and reduces the rate of glucose release, making it an effective target for glycemic control (Cisneros-Yupanqui et al. 2023).

Currently available synthetic α -amylase inhibitors, such as acarbose, miglitol, and voglibose, are widely used in clinical practice. However, their application is often limited due to associated gastrointestinal side effects, including bloating, diarrhea, and abdominal discomfort (Abu et al. 2025). Additionally, long-term use of these drugs may lead to poor patient compliance, highlighting the need for safer and more tolerable alternatives (Febriyanti et al. 2025a). In this context, plant-derived bioactive compounds have gained considerable attention as potential therapeutic agents due to their natural origin, biocompatibility, and reduced adverse effects. *Solanum lycopersicum* (tomato) is a widely consumed plant known for its rich phytochemical composition,

including flavonoids, phenolic acids, vitamins, and carotenoids such as lycopene (Febriyanti et al. 2025b). Lycopene, a potent antioxidant, has been extensively studied for its ability to mitigate oxidative stress, which plays a critical role in the pathogenesis of diabetes and its complications (Litewski et al. 2025a). Furthermore, flavonoids present in *S. lycopersicum* have demonstrated enzyme inhibitory activity, including α -amylase inhibition, thereby contributing to its antidiabetic potential (Litewski et al. 2025b).

Recent studies have highlighted the synergistic effects of these phytoconstituents in modulating key metabolic pathways associated with glucose homeostasis (Febriyanti et al. 2025d). The antioxidant properties of tomato extracts further enhance their therapeutic value by reducing oxidative damage and improving cellular function (Litewski et al. 2025c). Moreover, the accessibility, affordability, and dietary relevance of *S. lycopersicum* make it an attractive candidate for the development of functional foods and phytopharmaceutical formulations (Litewski et al. 2025d). Despite these promising attributes, systematic evaluation of its enzyme inhibitory activity and correlation with phytochemical content remains limited. Therefore, the present study aims to investigate the phytochemical profile and *in-vitro* α -amylase inhibitory activity of *Solanum lycopersicum* extract, providing scientific evidence for its potential application in the management of Type 2 Diabetes Mellitus (Litewski et al. 2025e).

PLANT MATERIAL AND AUTHENTICATION

The plant material of *Solanum lycopersicum* (family: Solanaceae) was collected from Ghargaon, Taluka Shrigonda, District Ahmednagar, Maharashtra, India. The whole fresh plant was collected during the appropriate growing



season and thoroughly washed with distilled water to remove adhering soil and contaminants. The collected plant material was initially shade-dried at room temperature for 5–7 days. Further drying was carried out under controlled conditions for up to 12 days at a temperature not exceeding 60°C to prevent degradation of thermolabile phytoconstituents.

Authentication of the plant material was performed based on its morphological and taxonomical characteristics, including leaf morphology, stem structure, fruit characteristics, and organoleptic properties such as color, odor, and taste. The plant was taxonomically identified as *Solanum lycopersicum*, belonging to the family Solanaceae. Although the original study confirms authentication through morphological evaluation, for standard scientific validation, plant specimens should ideally be authenticated by a qualified botanist and a voucher specimen deposited in a recognized herbarium for future reference. After complete drying, the plant material was coarsely powdered using a mechanical grinder and stored in airtight containers under dry and cool conditions to prevent moisture absorption and degradation of active constituents. Proper storage conditions are essential to maintain phytochemical stability and ensure reproducibility of experimental results. Similar methodologies for plant collection, authentication, and storage have been reported in recent phytopharmacological studies emphasizing standardization and quality control of herbal materials (Kashtoh and Baek 2023b), (Kalinovskii et al. 2023), (Dirir et al. 2022)

EXTRACTION METHOD

4.1 Type of Extraction (Soxhlet Extraction):

The extraction of phytoconstituents from *Solanum lycopersicum* fruit was carried out using the Soxhlet extraction method. The plant material was

first shade-dried and coarsely powdered using a mechanical grinder. Approximately 54 g of powdered drug was packed in a thimble prepared from filter paper and placed in the Soxhlet apparatus. The extraction was continued for 24 hours, consisting of nearly 50–56 cycles, until a constant cycle time was achieved, indicating exhaustive extraction.

Soxhlet extraction is a continuous hot extraction technique widely used for isolating bioactive compounds from plant materials due to its efficiency in repeated solvent percolation and complete extraction of phytochemicals.

4.2 Solvent Used (Ethanol Extraction):

Ethanol was used as the extraction solvent due to its ability to dissolve a wide range of polar and semi-polar phytoconstituents such as alkaloids, flavonoids, glycosides, tannins, and phenolic compounds.

After completion of extraction, the solvent was recovered using steam distillation, and the remaining extract was evaporated in a petri dish to obtain a dry crude extract. The dried extract was then stored and later used for phytochemical screening and biological evaluation.

Ethanol is commonly preferred in phytochemical studies because of its low toxicity, high extraction efficiency, and compatibility with biological assays (Mohamed et al. 2012), (Kazeem et al. 2013)

4.3 Percentage Yield Calculation:

The percentage yield of extract was calculated using the following formula:

$$\text{Percentage Yield (\%)} = \frac{\text{Weight of dried extract}}{\text{Weight of crude drug}} \times 100$$



Where:

- Weight of crude drug = 54 g
- Weight of dried extract = 9 g

This calculation helps in determining the efficiency of the extraction process and is an important parameter in standardization of herbal extracts.

4.4 Thin Layer Chromatography (TLC) Analysis:

Thin Layer Chromatography (TLC) analysis of the ethanolic extract of *Solanum lycopersicum* was performed to separate and identify the phytoconstituents present in the extract. Pre-coated silica gel 60 F254 TLC plates were used as the stationary phase. The plates were activated at 105°C for 30 minutes prior to use to remove any adsorbed moisture. The dried extract was dissolved in ethanol to obtain a suitable concentration. A small quantity of the sample was applied as a spot on the baseline (1 cm from the bottom edge) using a capillary tube. The mobile phase consisting of toluene: ethyl acetate: formic acid (5:4:1 v/v/v) was prepared and poured into a TLC chamber, which was previously saturated with the solvent system. The spotted TLC plate was placed vertically in the chamber and allowed to develop until the solvent front migrated approximately three-fourths of the plate length. After development, the plate was removed and air-dried. The separated components were visualized under UV light at 254 nm and 366 nm, and further confirmation was carried out using iodine vapors (Wagner and Bladt 1996), (Harborne 1984)

Rf Value Determination

The retention factor (Rf) values of the separated spots were calculated using the following equation:

$$Rf = \frac{\text{Distance travelled by solute}}{\text{Distance travelled by solvent front}}$$

4.5 In-vitro α -Amylase Inhibitory Assay:

Plant's inhibitory potential for α -amylase was determined by mixing various concentrations of the *solanum lycopersicum* extract with the enzyme, α -amylase, and starch solutions. After mixing 250 μ L of the sample solution with 250 μ L of 0.02 M PBS (pH 6.9) solution, which contained 250 U/mL of the α -amylase enzyme, the mixture was stored at 37°C for 20 min. After that, the mixture was incubated with 1% starch in PBS (pH 6.9) for 20 min at 37°C. Then, the solution was incubated at 90°C for 10 min after the addition of 500 μ L of di-nitro-salicylic acid. Boiled for the 20 min they show the red colour. After diluting the cooled reaction mixture with 5 mL of distilled water, the absorbance at 540 nm was determined. The IC₅₀ values were calculated, and the positive control used in this study was metformin.

% inhibition =

$$\frac{\text{Absorbance of control} - \text{Absorbance of standards}}{\text{Absorbance of control}} \times 100$$

Mode of inhibition: In one set of tubes, 250 μ L of the extract (5 mg/mL) was preincubated for 10 min at 25°C with 250 μ L of α -amylase solution. Using 250 μ L of phosphate buffer (pH 6.9), α -amylase was preincubated in an additional set of tubes. Increasing quantities of starch (0.30–5.0) in 250 μ L of solution (mg/mL) was introduced to initiate the reaction in both sets of reaction mixtures. After 500 μ L of acidified iodine was added to the mixture, the mixture was incubated for 10 minutes at 25°C to terminate the reaction. The absorbance was then measured at 620 nm. Using a starch standard curve and spectrophotometry, the amount of residual starch was calculated and converted to reaction velocities. A double reciprocal plot with V representing reaction velocity and (S)



representing substrate (Miller 1959), (Zohri et al. 2018).

RESULT:

Morphological Evaluation: The organoleptic evaluation was done by means of sense organs. This refers to the evaluation of drugs by colour, odour, size, shape, taste and special features including touch, texture etc.

Table 1 morphological evaluation of *solanum lycopersicum*

Parameter	observation
color	Red
Odour	Sweet, fruity, slightly smoky
shape	Round, oblate, pear-shaped, torpedo-shaped
Taste	Sweet-sour

Loss on drying:

The moisture content of *Solanum lycopersicum* powder was determined by the loss on drying method. The initial weight of the sample along with the porcelain dish was recorded as 64.44 g, and after drying at 100°C, the final weight was found to be 64.30 g.

The loss in weight was calculated to be 0.14 g, which corresponds to a percentage loss on drying of 14%.

This indicates the presence of a moderate amount of moisture in the sample, which may influence the stability and shelf-life of the plant material.

Determination of Ash Value:

The total ash value of *Solanum lycopersicum* powder was determined by complete incineration

of the sample. The weight of the empty dish was recorded as 17.80 g, and 1 g of the powdered drug was taken for analysis. After complete incineration, the weight of the dish along with ash was found to be 18.22 g.

The weight of the ash obtained was calculated as 0.42 g. The total ash value of the sample was found to be 42% w/w, indicating the presence of inorganic constituents such as mineral salts in the plant material.

Percentage Yield Calculation

The percentage yield of extract was calculated using the following formula:

$$\text{Percentage Yield (\%)} = \frac{\text{Weight of dried extract}}{\text{Weight of crude drug}} \times 100$$

Where:

Weight of crude drug = 54 g

Weight of dried extract = 9 g

Calculation:

$$\text{Percentage Yield (\%)} = \frac{9}{54} \times 100 = 16.67\%$$

The percentage yield of the ethanolic extract of *Solanum lycopersicum* was found to be 16.67%, indicating efficient extraction of bioactive phytoconstituents using the Soxhlet extraction method. The relatively high yield may be attributed to the effectiveness of ethanol in extracting a broad spectrum of phytochemicals.

Qualitative Phytochemical Screening

Table 2 phytochemical Screening of *solanum lycopersicum*

Sr no.	Phytochemical Constituents	Test Performed	Observation	Result
1	Alkaloids	Mayer's Test	Cream-colored precipitate formed	Present (+)
2	Flavonoids	Alkaline Reagent Test	Yellow color turning colorless with acid	Present (+)
3	Tannins	Ferric Chloride Test	Blue-black/greenish coloration	Present (+)



4	Saponins	Foam Test	Stable persistent foam formed	Present (+)
5	Glycoside	Keller–Killiani Test	Reddish-brown ring at interface	Present (+)

Quantitative Phytochemical Analysis:

Total Phenolic Content (TPC)

Table 3 Total Phenolic Content of Solanum lycopersicum Extract

Sr no	Concentration (µg/mL)	Absorbance (765 nm)
1	20	0.215
2	40	0.398
3	60	0.562
4	80	0.731
5	100	0.895

Total Phenolic Content = 48.72 ± 1.25 mg GAE/g extract

Total Flavonoid Content (TFC):

Table 4 Total Flavonoid Content of Solanum lycopersicum Extract

Sr no	Concentration (µg/mL)	Absorbance (510 nm)
1	20	0.182
2	40	0.346
3	60	0.521
4	80	0.684
5	100	0.842

Total Flavonoid Content = 32.15 ± 0.98 mg QE/g extract

Thin layer chromatography:



Figure 1 Thin layer chromatography of solanum lycopersicum

Thin Layer Chromatography (TLC) of the ethanolic extract of *Solanum lycopersicum* revealed the presence of distinct phytoconstituents based on their migration pattern on the silica gel plate. The separated compounds showed different Rf values, indicating variation in polarity and chemical nature.

Two main spots were observed corresponding to carotenoid compounds. The Rf values were calculated using the standard formula:

$$R_f = \frac{\text{Distance travelled by solute}}{\text{Distance travelled by solvent front}}$$

The observed Rf values suggest the presence of lycopene and carotene, which are major bioactive constituents of tomato

Table 5 TLC of solanum lycopersicum

Sr. No	Distance travelled by compound	Solute travel by solvent	RF value	Compound
1	2	3.3	0.607	lycopene
2	3	3.3	0.9090	Carotene

In-vitro α-Amylase Inhibitory Activity:

The inhibitory effect of *Solanum lycopersicum* extract on α-amylase enzyme activity was evaluated at different concentrations. The absorbance was measured at 540 nm, and the percentage inhibition was calculated in comparison with the control.

The results demonstrated that the extract exhibited significant α-amylase inhibitory activity, which

increased with concentration. The highest inhibition was observed in the sample (S) at 10 $\mu\text{g/mL}$ (92.07%), followed by T3 (90.01%), T2 (89.22%), and T1 (87.32%).

These findings indicate that the extract possesses strong antidiabetic potential due to its ability to inhibit carbohydrate hydrolyzing enzymes.

Table 6 in vitro study of alpha-amylase inhibitory activity by solanum lycopersicum

Sr. No	Sample	Concentration ($\mu\text{g /ml}$)	Wavelength (nm)	Absorbance (nm)	Inhibitory action
1	Control	10	540	0.631	0.00%
2	S	10	540	0.050	92.07%
3	T1	10	540	0.080	87.32%
4	T2	25	540	0.068	89.22%
5	T3	50	540	0.063	90.01%

Graph shows the relationship between concentration and percentage inhibition of α -amylase activity by *Solanum lycopersicum* extract.

The graph indicates a dose-dependent increase in inhibitory activity, suggesting effective enzyme inhibition at higher concentrations.

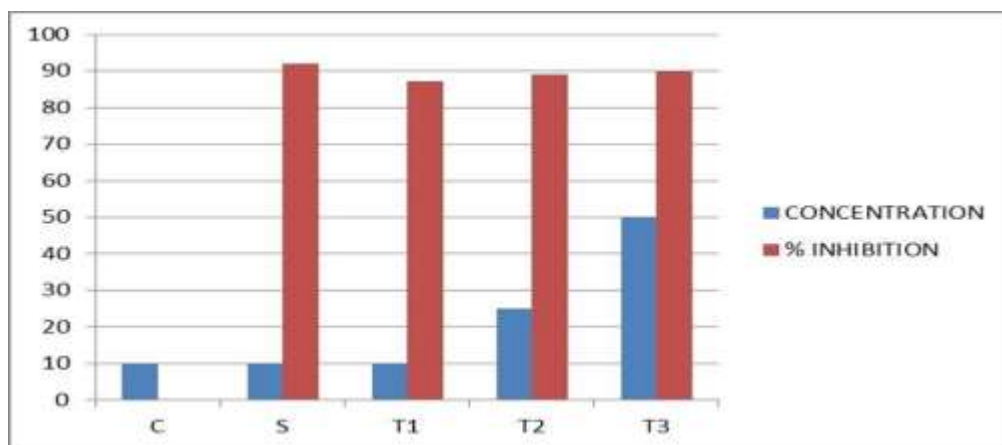


Figure 2 Graph of in-vitro alpha amylase inhibitory activity of solanum lycopersicum

DISCUSSION

The present study was carried out to evaluate the phytochemical composition and *in-vitro* α -amylase inhibitory activity of *Solanum lycopersicum* extract. The findings of this study clearly demonstrate that the plant possesses significant bioactive potential, supporting its traditional use in the management of diabetes. The extraction using ethanol yielded a considerable amount of crude extract, indicating the efficiency of Soxhlet extraction in isolating both polar and semi-polar phytoconstituents. Ethanol is widely reported as an effective solvent due to its ability to extract phenolics, flavonoids, and glycosides,

which are known for their therapeutic properties. Phytochemical screening revealed the presence of important secondary metabolites such as alkaloids, flavonoids, tannins, saponins, and glycosides. These compounds are well-known for their antioxidant and enzyme inhibitory properties, which play a crucial role in antidiabetic activity. The presence of flavonoids and phenolic compounds is particularly important, as they are reported to inhibit carbohydrate-hydrolyzing enzymes and reduce oxidative stress. The TLC analysis further confirmed the presence of bioactive compounds, with R_f values corresponding to lycopene and carotene, which are



major carotenoids present in tomato. These compounds are strong antioxidants and are known to protect pancreatic β -cells from oxidative damage, thereby improving insulin function. The *in-vitro* α -amylase inhibitory assay demonstrated that the extract exhibited significant enzyme inhibition, with maximum inhibition of 92.07%, which is comparable to the standard drug metformin.

This indicates that the extract can effectively delay carbohydrate digestion and glucose absorption, thereby controlling postprandial hyperglycemia. The mechanism of α -amylase inhibition involves blocking the breakdown of starch into glucose, which ultimately reduces the rise in blood glucose levels. These inhibitors are often referred to as “starch blockers,” as they interfere with enzyme-substrate interaction. Furthermore, the high inhibitory activity observed in the extract may be attributed to the synergistic effect of multiple phytoconstituents such as flavonoids, phenolics, and carotenoids. These compounds not only inhibit enzymes but also exhibit antioxidant activity, which helps in reducing oxidative stress associated with diabetes. The results obtained in this study are in agreement with previous reports, which suggest that *Solanum lycopersicum* possesses significant antidiabetic and antioxidant properties due to the presence of lycopene and other bioactive compounds. However, certain limitations exist, such as the lack of *in-vivo* studies and detailed mechanism-based enzyme kinetics. Further studies involving IC_{50} determination, molecular docking, and clinical evaluation are required to validate these findings.

CONCLUSION:

The present research provides strong scientific evidence that *Solanum lycopersicum* (tomato) is a rich source of biologically active phytoconstituents and possesses significant

antidiabetic potential. The study successfully combined phytochemical profiling with *in-vitro* biological evaluation, offering a comprehensive understanding of the plant's therapeutic value. The extraction process using ethanol and Soxhlet apparatus proved to be efficient, yielding 16.67% extract, which indicates effective recovery of both polar and semi-polar compounds. Standardization parameters such as loss on drying (14%) and ash value (42%) reflect acceptable physicochemical characteristics, although the relatively high ash value suggests a notable presence of inorganic matter, which should be further evaluated for purity and quality control in future studies. Qualitative phytochemical screening confirmed the presence of key secondary metabolites including alkaloids, flavonoids, tannins, saponins, and glycosides. Quantitative analysis revealed a considerable amount of total phenolic content (48.72 mg GAE/g extract) and total flavonoid content (32.15 mg QE/g extract). These compounds are widely recognized for their antioxidant and enzyme inhibitory properties, which are crucial in managing metabolic disorders like diabetes. The presence of these bioactive molecules indicates that the plant extract has a strong biochemical basis for therapeutic action. Thin Layer Chromatography (TLC) analysis further validated the phytochemical composition by identifying major carotenoids such as lycopene and carotene, based on their R_f values. These compounds are known for their potent antioxidant activity, which helps in reducing oxidative stress—a key factor in the development and progression of diabetes and its complications. Their presence strengthens the functional and medicinal value of the extract. The most significant finding of this study lies in the *in-vitro* α -amylase inhibitory activity. The extract demonstrated a very high level of enzyme inhibition (up to 92.07%), which is comparable to standard antidiabetic drugs. The inhibition was



clearly concentration-dependent, indicating a dose-response relationship. This suggests that the extract can effectively delay the breakdown of starch into glucose, thereby reducing postprandial hyperglycemia. The mechanism of action is likely due to the interaction of polyphenolic compounds with the active site of the enzyme, preventing substrate binding and enzymatic activity.

Importantly, the study highlights the synergistic effect of multiple phytoconstituents. Instead of a single active compound, a combination of flavonoids, phenolics, and carotenoids appears to contribute collectively to both enzyme inhibition and antioxidant activity. This synergy is a key advantage of plant-based therapeutics over synthetic drugs, which often act through a single pathway and may produce side effects. Despite these promising results, the study acknowledges certain limitations. The findings are restricted to in-vitro analysis, and therefore, do not fully represent the complex biological interactions occurring in living systems. Parameters such as bioavailability, metabolism, pharmacokinetics, and long-term safety were not assessed. Additionally, detailed enzyme kinetics (such as IC_{50} values and inhibition type) and molecular-level interactions were not extensively explored.

In conclusion, this research establishes *Solanum lycopersicum* as a potent natural source of antidiabetic agents with strong α -amylase inhibitory and antioxidant properties. It supports the potential use of tomato-based extracts in the development of functional foods, nutraceuticals, and phytopharmaceutical formulations for diabetes management. However, to translate these findings into clinical application, further studies including *in-vivo* experiments, toxicity evaluation, molecular docking, and human clinical trials are essential. Such investigations will help in confirming efficacy, ensuring safety, and enabling

the development of standardized, effective, and affordable plant-based therapeutic alternatives.

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