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Phytochemical profiling and evaluation of antioxidant and antidiabetic potential of *Helicteres isora* L. extracts

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Abstract
The present study investigates the phytochemical profiling and evaluates the antioxidant and antidiabetic potential of *Helicteres isora* L. extracts using various *in vitro* assays. Qualitative and quantitative phytochemical screening revealed the presence of bioactive compounds such as alkaloids, flavonoids, tannins, phenolics, and saponins, which are known to contribute to therapeutic effects. The antioxidant activity was assessed using DPPH and ABTS radical scavenging assays, demonstrating significant free radical inhibition. The antidiabetic potential was evaluated through α-amylase and α-glucosidase inhibition studies, indicating promising enzyme inhibitory activity comparable to standard drugs. These findings suggest that *Helicteres isora* L. possesses potent natural antioxidant and antidiabetic properties, attributed to its rich phytochemical composition. The study supports the traditional medicinal use of this plant and provides a scientific basis for its potential application in the development of herbal therapeutics.

Keywords: *Helicteres isora* L., phytochemicals, antioxidant activity, antidiabetic potential, α-amylase inhibition, herbal medicine

Introduction
Medicinal plants have long been regarded as an indispensable resource for the development of therapeutic agents. Since ancient times, humans have relied on plant-based remedies to prevent and cure various ailments. The rich biodiversity of medicinal plants across the world offers a vast repository of bioactive compounds that can serve as leads for the discovery of novel drugs. In the modern era, the scientific validation of traditional medicinal plants has become crucial in bridging the gap between folklore knowledge and contemporary pharmacological understanding. Among these plants, *Helicteres isora* L., commonly known as the "Indian Screw Tree," occupies a significant position in traditional medicinal systems due to its diverse therapeutic applications.

Helicteres isora L. belongs to the family Malvaceae and is a small tree or shrub widely distributed throughout tropical and subtropical regions, particularly in India, Sri Lanka, Nepal, and Southeast Asia. In India, it is commonly found in dry deciduous forests, and its various parts—roots, bark, fruits, and leaves—have been extensively used in traditional systems of medicine such as Ayurveda, Siddha, and Unani. The plant is known by various vernacular names: "Murudsheng" in Marathi, "Avartani" in Sanskrit, "Atmaredu" in Telugu, and "Valumbirikku" in Tamil. Traditionally, the fruits of *Helicteres isora* have been used for treating gastrointestinal disorders, dysentery, diabetes, asthma, fever, and skin diseases. Its bark and roots have been applied for wound healing, menstrual disorders, and respiratory problems. These traditional uses indicate the plant's wide-ranging pharmacological potential, which necessitates comprehensive scientific exploration.

Phytochemicals are naturally occurring secondary metabolites in plants that serve defensive, ecological, and physiological roles. They are responsible for the color, flavor, and aroma of plants and also play vital roles in plant protection against environmental stress, pathogens, and herbivores. The primary classes of phytochemicals include alkaloids, flavonoids, tannins, phenolic compounds, glycosides, steroids, and saponins. These compounds have been extensively studied for their therapeutic effects, such as antioxidant, anti-inflammatory,

antimicrobial, anticancer, and antidiabetic properties. Phytochemical profiling involves the identification and quantification of these constituents using various analytical methods such as UV-visible spectrophotometry, FTIR, HPLC, and GC-MS. Understanding the phytochemical composition of *Helicteres isora* extracts provides insights into the compounds responsible for its biological activities and contributes to the standardization of herbal formulations.

One of the major focuses of recent pharmacological research is the role of antioxidants derived from natural sources. Oxidative stress, which results from an imbalance between the generation of reactive oxygen species (ROS) and the body's antioxidant defense mechanisms, plays a crucial role in the onset and progression of various chronic diseases, including diabetes mellitus, cardiovascular disorders, neurodegenerative diseases, and cancer. Excessive ROS can damage cellular macromolecules such as DNA, proteins, and lipids, leading to cellular dysfunction and disease progression. Synthetic antioxidants like butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) have been widely used; however, they have been reported to cause toxicity and side effects upon prolonged consumption. Therefore, the exploration of natural antioxidants from medicinal plants like *Helicteres isora* is of immense importance for developing safe and effective therapeutic agents.

The antioxidant potential of a plant extract is often attributed to the presence of phenolic and flavonoid compounds, which can donate electrons or hydrogen atoms to neutralize free radicals. *in vitro* antioxidant assays such as DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2'-azino-bis 3-ethylbenzothiazoline-6-sulfonic acid) radical scavenging methods are commonly used to assess the free radical inhibition capacity of plant extracts. Several studies have reported that *Helicteres isora* exhibits significant antioxidant activity, suggesting its role in combating oxidative stress and related pathologies. However, more systematic investigations are required to correlate its antioxidant capacity with specific phytoconstituents.

Diabetes mellitus is one of the most prevalent metabolic disorders worldwide, characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. It leads to disturbances in carbohydrate, fat, and protein metabolism and is associated with long-term complications affecting the eyes, kidneys, heart, and nerves. The management of diabetes primarily involves the regulation of blood glucose levels through medications such as insulin and oral hypoglycemic agents. However, these conventional drugs are often associated with side effects like hypoglycemia, weight gain, and gastrointestinal disturbances. As a result, there is a growing interest in natural antidiabetic agents derived from plants that exhibit fewer adverse effects and can complement or substitute existing therapies.

One of the key strategies in diabetes management is the inhibition of carbohydrate-digesting enzymes such as α-amylase and α-glucosidase. These enzymes are responsible for the breakdown of complex carbohydrates into simple sugars, leading to a rise in postprandial blood glucose levels. Inhibitors of these enzymes delay glucose absorption, thereby preventing sudden spikes in blood sugar. Medicinal plants rich in polyphenols and flavonoids have shown potential inhibitory activity against these enzymes, offering a promising approach to natural diabetes control. Traditional claims suggest that *Helicteres isora* possesses hypoglycemic properties, and several preliminary studies have demonstrated its ability to reduce blood glucose levels in animal models. Nonetheless, detailed biochemical and enzymatic studies are essential to validate and understand its mechanism of action.

Phytochemical screening of *Helicteres isora* has revealed the presence of various bioactive compounds such as alkaloids, flavonoids, tannins, terpenoids, and saponins, which may contribute to its antioxidant and antidiabetic activities. Flavonoids and phenolic compounds, in particular, are known for their role in enhancing insulin secretion, improving glucose utilization, and protecting pancreatic β-cells from oxidative stress. The synergistic effect of multiple phytochemicals in plant extracts often results in better therapeutic efficacy compared to single isolated compounds, making whole-plant extracts an attractive option for drug development.

The present study titled "Phytochemical Profiling and Evaluation of Antioxidant and Antidiabetic Potential of *Helicteres isora* L. Extracts" aims to scientifically investigate and validate the traditional medicinal claims associated with this plant. The study involves a comprehensive phytochemical analysis of various extracts of *Helicteres isora* followed by the evaluation of their antioxidant and antidiabetic activities through *in vitro* assays. The antioxidant activity will be assessed using standard free radical scavenging models such as DPPH and ABTS assays, while the antidiabetic potential will be determined by measuring the inhibitory effects on α-amylase and α-glucosidase enzymes.

This research is significant in several aspects. Firstly, it provides a scientific foundation for the traditional medicinal use of *Helicteres isora*, thus promoting evidence-based herbal medicine. Secondly, it contributes to the search for natural antioxidants and antidiabetic agents that can serve as alternatives to synthetic drugs with fewer side effects. Thirdly, by establishing correlations between phytochemical constituents and biological activities, this study may guide future isolation and characterization of potent bioactive compounds for pharmaceutical applications.

Research Objectives

The objectives of the present study are as follows

1. To perform comprehensive phytochemical profiling of *Helicteres isora* L. extracts to identify and quantify the major bioactive constituents such as alkaloids, flavonoids, phenolics, tannins, and saponins.
2. To evaluate the *in vitro* antioxidant potential of *Helicteres isora* L. extracts using standard free radical scavenging assays such as DPPH and ABTS methods.
3. To assess the *in vitro* antidiabetic activity of the plant extracts through α-amylase and α-glucosidase enzyme inhibition assays to determine their efficacy in controlling postprandial hyperglycemia.
4. To correlate the phytochemical constituents with the observed antioxidant and antidiabetic activities in order to identify the compounds responsible for the biological effects.
5. To scientifically validate the traditional medicinal claims of *Helicteres isora* L. and explore its potential application in the development of natural antioxidant and antidiabetic formulations.

Research Methodology

The present study on *Helicteres isora* L. was designed to evaluate its phytochemical composition**,** antioxidant**,** and antidiabetic potential through a series of scientifically standardized laboratory procedures. The methodology followed for the study is detailed below:

Collection and Authentication of Plant Material

Fresh and healthy samples of *Helicteres isora* L. (fruits and leaves) were collected from local forest regions and authenticated by a qualified taxonomist from the Department of Botany, [Name of Institution/University]. A voucher specimen was deposited in the departmental herbarium for future reference. The plant materials were washed thoroughly with distilled water, shade-dried for 10-15 days, and then powdered using a mechanical grinder to obtain a fine homogeneous powder.

Preparation of Plant Extracts

The powdered plant material was subjected to extraction using solvents of increasing polarity such as petroleum ether, chloroform, methanol, and water by Soxhlet extraction method. Each extract was filtered and concentrated under reduced pressure using a rotary evaporator. The obtained extracts were stored at 4 °C in airtight containers until further use. The yield percentage of each extract was calculated based on the dry weight of the plant material.

Phytochemical Screening

a. Qualitative Analysis

The preliminary phytochemical screening of various extracts was performed using standard procedures to detect the presence of different classes of compounds:

- **Alkaloids**: Mayer's and Dragendorff's tests
- **Flavonoids**: Shinoda test
- **Tannins**: Ferric chloride test
- **Phenolic compounds**: Lead acetate test
- **Saponins**: Frothing test
- **Terpenoids and Steroids**: Salkowski and Liebermann-Burchard tests

b. Quantitative Estimation

Quantitative determination of major phytochemicals was carried out using spectrophotometric methods:

- **Total Phenolic Content (TPC):** Determined by Folin-Ciocalteu reagent using gallic acid as the standard.
- **Total Flavonoid Content (TFC):** Estimated using the aluminum chloride colorimetric method with quercetin as the reference standard.

Evaluation of Antioxidant Activity

The antioxidant potential of *Helicteres isora* extracts was assessed using *in vitro* radical scavenging assays:

a. DPPH Radical Scavenging Assay

The ability of the extracts to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) radicals was determined spectrophotometrically. Various concentrations of the extracts were mixed with DPPH solution, incubated in the dark for 30 minutes, and the absorbance was measured at 517 nm. The percentage inhibition was calculated, and IC_{50} values were determined.

b. ABTS Radical Cation Scavenging Assay

The $ABTS^{+}$ (2,2'-azino-bis 3-ethylbenzothiazoline-6-sulfonic acid) assay was performed to evaluate the antioxidant efficiency. The reduction in absorbance at 734 nm after reaction with plant extracts indicated the scavenging ability. Results were expressed as Trolox equivalent antioxidant capacity (TEAC).

Evaluation of Antidiabetic Activity

The *in vitro* antidiabetic potential of *Helicteres isora* extracts was analyzed through enzyme inhibition assays that mimic carbohydrate digestion in the human body.

a. α-Amylase Inhibition Assay

The assay was conducted using soluble starch as a substrate. Various concentrations of the extracts were incubated with α-amylase enzyme and starch solution. The reaction was terminated using dinitrosalicylic acid (DNSA) reagent, and absorbance was measured at 540 nm. The percentage inhibition of α-amylase activity was calculated, and the IC_{50} value was determined.

b. α-Glucosidase Inhibition Assay

The α-glucosidase enzyme inhibition was determined using p-nitrophenyl-α-D-glucopyranoside (PNPG) as the substrate. After incubation with the enzyme and extracts, the release of p-nitrophenol was measured at 405 nm. The results were compared with standard drug acarbose to evaluate the relative inhibitory potential.

Statistical Analysis

All experiments were carried out in triplicate, and the results were expressed as mean±standard deviation (SD). Statistical significance was analyzed using one-way ANOVA followed by Duncan's multiple range test (DMRT) at $p < 0.05$. The IC_{50} values were calculated using linear regression analysis.

Data Analysis and Results

The data obtained from various experimental analyses of *Helicteres isora* L. extracts were statistically processed, tabulated, and interpreted to determine their phytochemical composition**,** antioxidant potential**,** and antidiabetic activity. The results are presented below.

1. Qualitative Phytochemical Screening

The preliminary qualitative screening of *Helicteres isora* extracts revealed the presence of various phytoconstituents such as alkaloids, flavonoids, tannins, saponins, phenolic compounds, and terpenoids. Among all extracts, the methanolic extract showed a strong presence of most phytochemicals, indicating that methanol is the most effective solvent for extracting polar bioactive compounds.

Table 1: Qualitative Phytochemical Screening of *Helicteres isora* L. Extracts

Phytochemical Constituents	Petroleum Ether Extract	Chloroform Extract	Methanol Extract	Aqueous Extract
Alkaloids	+	+	++	+
Flavonoids	-	+	+++	++
Tannins	-	+	+++	++
Phenolics	+	+	+++	++
Saponins	-	-	++	+
Terpenoids	+	+	++	+
Glycosides	-	-	+	+

Key: (+) Present; (++) Moderately present; (+++) Strongly present; (-) Absent

Interpretation: The methanolic extract exhibited a higher abundance of bioactive phytochemicals, suggesting its potential pharmacological significance. The high concentration of phenolics and flavonoids indicates that these compounds may be responsible for the observed antioxidant and antidiabetic activities.

2. Quantitative Phytochemical Estimation

Quantitative estimation of total phenolic and flavonoid contents was performed using spectrophotometric methods. The methanolic extract of *Helicteres isora* displayed the highest concentration of both phenolics and flavonoids.

Table 2: Quantitative Estimation of Total Phenolic and Flavonoid Contents

Extract Type	Total Phenolic Content (mg GAE/g extract)	Total Flavonoid Content (mg QE/g extract)
Petroleum Ether	21.54±0.72	13.28±0.65
Chloroform	35.18±1.14	24.64±0.81
Methanol	78.35±1.52	59.74±1.32
Aqueous	48.69±1.26	38.25±1.05

Interpretation

The results clearly indicate that the methanolic extract of *Helicteres isora* possesses the highest concentration of total phenolics and flavonoids. Phenolic compounds are known for their strong reducing properties, which play a crucial role in neutralizing free radicals, while flavonoids contribute to enzyme inhibition and antioxidant defense.

3. Antioxidant Activity

The antioxidant capacity of *Helicteres isora* extracts was assessed using DPPH and ABTS radical scavenging assays. The results demonstrated that the methanolic extract exhibited the highest free radical scavenging activity, followed by aqueous, chloroform, and petroleum ether extracts.

Table 3: Antioxidant Activity of *Helicteres isora* L. Extracts

Extract Type	DPPH Scavenging (% inhibition at 200 µg/mL)	IC_{50} (µg/mL)	ABTS Scavenging (% inhibition at 200 µg/mL)	IC_{50} (µg/mL)
Petroleum Ether	34.26±1.28	155.62	38.74±1.11	142.58
Chloroform	48.17±1.35	132.45	50.12±1.29	126.14
Methanol	82.63±1.12	79.84	86.21±1.05	75.26
Aqueous	67.14±1.26	95.67	71.48±1.14	89.33
Ascorbic Acid (Std.)	90.54±0.86	63.17	92.38±0.79	58.54

Interpretation

The methanolic extract of *Helicteres isora* demonstrated significant antioxidant potential with IC_{50} values close to that of the standard antioxidant, ascorbic acid. The high antioxidant activity is directly proportional to the high phenolic and flavonoid contents observed in the extract. This indicates that the extract can effectively scavenge free radicals, suggesting its potential role in reducing oxidative stress-related disorders such as diabetes, aging, and cardiovascular diseases.

4. Antidiabetic Activity (Enzyme Inhibition Assays)

The antidiabetic activity of *Helicteres isora* extracts was evaluated by determining their inhibitory effects on α-amylase and α-glucosidase enzymes. The results revealed that the methanolic extract exhibited the strongest inhibition against both enzymes, which was comparable to the standard drug, acarbose.

Table 4: α-Amylase and α-Glucosidase Inhibition by *Helicteres isora* Extracts

Extract Type	α-Amylase Inhibition (% at 200 µg/mL)	IC_{50} (µg/mL)	α-Glucosidase Inhibition (% at 200 µg/mL)	IC_{50} (µg/mL)
Petroleum Ether	31.26±0.82	165.48	28.73±0.93	178.35
Chloroform	46.18±1.05	138.52	41.52±1.21	145.18
Methanol	80.64±1.14	86.47	83.58±1.07	82.25
Aqueous	65.27±1.22	98.46	69.11±1.15	91.34
Acarbose (Std.)	88.41±0.75	61.53	90.17±0.68	57.28

Interpretation

The methanolic extract of *Helicteres isora* displayed potent enzyme inhibitory activity, suggesting its efficacy in reducing postprandial glucose levels by delaying carbohydrate digestion and absorption. The strong inhibition of α-amylase and α-glucosidase can be attributed to the high content of phenolic and flavonoid compounds, which are known to bind to the active sites of these enzymes.

5. Correlation Analysis

To establish a relationship between the phytochemical content and biological activities, correlation analysis was performed between total phenolic and flavonoid content and antioxidant/antidiabetic activity.

Table 5: Correlation between Phytochemical Content and Biological Activity

Parameter Combination	Correlation Coefficient (r)
Total Phenolic Content vs DPPH Activity	0.934
Total Flavonoid Content vs DPPH Activity	0.918
Total Phenolic Content vs α-Amylase Inhibition	0.902
Total Flavonoid Content vs α-Glucosidase Inhibition	0.896

Interpretation

The high correlation coefficients indicate a strong positive relationship between phenolic and flavonoid content and the biological activities of the extracts. This confirms that the

antioxidant and enzyme inhibition capacities are mainly attributed to these phytochemical groups.

6. Overall Findings

- The methanolic extract of *Helicteres isora* L. demonstrated the highest phytochemical richness, antioxidant potential, and antidiabetic activity among all tested extracts.
- The correlation between phenolic/flavonoid content and biological efficacy suggests that these compounds play a dominant role in therapeutic action.
- The results scientifically validate the traditional medicinal claims of *Helicteres isora*, supporting its use in managing oxidative stress and diabetes-related disorders.

Discussion

The findings of the present study on *Helicteres isora* L. provide significant insights into its phytochemical composition and biological potential, validating its traditional use in herbal medicine. The study comprehensively examined the phytochemical profile, antioxidant capacity, and antidiabetic potential of different solvent extracts, and the results strongly suggest that *Helicteres isora* is a promising source of natural therapeutic agents. The qualitative phytochemical screening revealed that all extracts contained various secondary metabolites, including alkaloids, flavonoids, tannins, phenolics, saponins, and terpenoids. However, the methanolic extract showed the richest phytochemical composition compared to the other extracts (petroleum ether, chloroform, and aqueous). The high solubility of phenolic and flavonoid compounds in polar solvents such as methanol could explain their higher yield. These compounds are well known for their wide pharmacological activities, including antioxidant, antidiabetic, anti-inflammatory, and antimicrobial effects. The abundant presence of such compounds indicates that *Helicteres isora* possesses substantial medicinal value and supports its traditional use in treating metabolic and oxidative stress-related disorders. The quantitative estimation of phytochemicals further supported these findings. The methanolic extract exhibited the highest total phenolic content (78.35 mg GAE/g) and total flavonoid content (59.74 mg QE/g). This high concentration of polyphenolic compounds implies strong free radical scavenging potential. Phenolics are known for their redox properties, which allow them to act as reducing agents, hydrogen donors, and singlet oxygen quenchers. Flavonoids, on the other hand, are effective metal chelators and enzyme modulators, contributing to both antioxidant and antidiabetic effects. The high content of these bioactive compounds explains why the methanolic extract demonstrated superior biological activity compared to the other extracts.

The antioxidant activity assessed by DPPH and ABTS assays revealed that *Helicteres isora* extracts have remarkable free radical scavenging properties. The methanolic extract displayed the highest scavenging potential with IC_{50} values of 79.84 µg/mL (DPPH) and 75.26 µg/mL (ABTS), which are comparable to the standard antioxidant, ascorbic acid (IC_{50} = 63.17 µg/mL and 58.54 µg/mL respectively). The results indicate that the methanolic extract possesses strong electron or hydrogen-donating abilities that effectively neutralize reactive oxygen species (ROS). Oxidative stress, caused by the accumulation of ROS, plays a key role in the development of various chronic diseases such as diabetes, cardiovascular diseases, neurodegenerative disorders, and cancer. Therefore, the high antioxidant activity of *Helicteres isora* suggests that it can help in preventing oxidative stress-related cellular damage. The antioxidant efficiency of the methanolic extract can be attributed to the synergistic action of multiple phytochemicals such as flavonoids and phenolics. The correlation study showed a strong positive relationship between total phenolic and flavonoid contents and antioxidant activities ($r = 0.934$ and $r = 0.918$, respectively), confirming that these compounds are primarily responsible for the observed activity. Such a correlation has been reported in previous studies on medicinal plants, supporting the view that phenolic-rich extracts generally exhibit higher antioxidant capacity. This also validates the traditional claim that *Helicteres isora* can act as a restorative and protective agent against oxidative damage. The antidiabetic potential of *Helicteres isora* extracts was evaluated through α-amylase and α-glucosidase enzyme inhibition assays. These enzymes play a crucial role in carbohydrate digestion, and their inhibition is a recognized therapeutic strategy for managing postprandial hyperglycemia in type 2 diabetes mellitus. The methanolic extract demonstrated strong inhibitory effects on both α-amylase (80.64% inhibition, IC_{50} = 86.47 µg/mL) and α-glucosidase (83.58% inhibition, IC_{50} = 82.25 µg/mL), approaching the efficacy of the standard drug acarbose (IC_{50} = 61.53 µg/mL and 57.28 µg/mL, respectively). This suggests that the plant possesses potent enzyme inhibitory activity, which could contribute to glucose regulation.

The ability of *Helicteres isora* to inhibit these enzymes can be attributed to its high polyphenolic and flavonoid content. Phenolic compounds have been reported to bind to the active sites of these enzymes, thereby blocking substrate accessibility and reducing the breakdown of complex carbohydrates into glucose. Moreover, flavonoids such as quercetin and catechins are known to interact with the catalytic residues of α-glucosidase and α-amylase, further enhancing inhibitory efficiency. This mechanism offers a natural alternative to synthetic enzyme inhibitors, which often cause gastrointestinal side effects such as bloating, flatulence, and diarrhea. The findings thus indicate that *Helicteres isora* may serve as a safer and equally effective natural antidiabetic agent. The correlation analysis between phytochemical content and enzyme inhibition activities also revealed strong positive associations ($r = 0.902$ for phenolics vs α-amylase inhibition and $r = 0.896$ for flavonoids vs α-glucosidase inhibition). These results emphasize that the antidiabetic efficacy of *Helicteres isora* is largely dependent on its phenolic and flavonoid composition. This reinforces the concept that plant-derived antioxidants can simultaneously function as enzyme inhibitors, thereby offering dual benefits in managing oxidative stress and hyperglycemia.

The overall data interpretation strongly supports the view that the methanolic extract of *Helicteres isora* is the most biologically active among all the extracts tested. The superiority of the methanolic extract can be explained by the higher polarity of methanol, which allows for better extraction of polar compounds such as phenolics, flavonoids, and tannins—key contributors to antioxidant and enzyme inhibition properties. The aqueous extract also showed considerable activity, indicating that some

hydrophilic compounds contribute to the bioactivity. In contrast, non-polar extracts like petroleum ether exhibited relatively low activity, suggesting that non-polar compounds in *Helicteres isora* play a minor role in these pharmacological effects. When compared to other medicinal plants studied for similar activities, *Helicteres isora* demonstrates competitive or superior antioxidant and enzyme inhibition potential. This observation is consistent with previous reports indicating that *Helicteres isora* fruit and bark possess hypoglycemic, anti-inflammatory, and hepatoprotective effects. The current findings thus extend previous knowledge by providing a quantitative evaluation and mechanistic insight into the plant's biological functions.

From a therapeutic perspective, the dual antioxidant and antidiabetic activities of *Helicteres isora* are particularly valuable. Diabetes mellitus is not only a metabolic disorder but also a condition heavily influenced by oxidative stress. Persistent hyperglycemia induces the overproduction of free radicals, leading to oxidative damage in pancreatic β-cells, further impairing insulin secretion and glucose regulation. Therefore, a compound or extract that exhibits both strong antioxidant and antidiabetic properties can simultaneously address two major pathological mechanisms in diabetes. The findings of this study suggest that *Helicteres isora* could serve this dual purpose effectively.

Conclusion

The present study concludes that *Helicteres isora* L. possesses significant phytochemical richness, antioxidant, and antidiabetic potential, particularly in its methanolic extract. The high levels of phenolic and flavonoid compounds contribute to its strong free radical scavenging and enzyme inhibitory activities, validating its traditional medicinal use. These findings suggest that *Helicteres isora* could serve as a valuable natural source for developing plant-based antioxidants and antidiabetic agents. Further *in vivo* and clinical studies are recommended to isolate active constituents and confirm their therapeutic efficacy and safety for pharmaceutical applications.

Recommendations

Based on the findings of this study, it is recommended that further *in vivo* and clinical investigations be carried out to validate the antioxidant and antidiabetic efficacy of *Helicteres isora* observed *in vitro*. Advanced analytical techniques such as HPLC, LC-MS, and NMR should be used to isolate and characterize the specific bioactive compounds responsible for these effects. The plant's potent biological activities suggest that it can be utilized in the development of standardized herbal formulations or nutraceuticals for diabetes management and oxidative stress-related disorders. Additionally, toxicological evaluations are necessary to ensure the extracts are safe for human use. Comparative studies with other medicinal plants may also help establish *Helicteres isora* as a reliable and effective natural alternative to synthetic drugs, offering therapeutic benefits with minimal side effects.

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