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Research Article

Optimization of Polyherbal Extraction of Gymnema sylvestre, Momordica charantia, and Syzygium cumini for Antidiabetic Phytoconstituents Using Maceration Technique and Evaluation of α-Glucosidase Inhibitory Activity

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ABSTRACT:

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia due to defects in insulin secretion or insulin resistance. The prevalence of diabetes is increasing globally, particularly in developing countries, leading to severe complications such as cardiovascular diseases, neuropathy, nephropathy, and retinopathy. Herbal medicines have gained significant importance in the management of diabetes due to their safety, availability, and minimal side effects compared to synthetic drugs. The present study focuses on the optimization of polyherbal extraction of Gymnema sylvestre, Momordica charantia, and Syzygium cumini using the maceration technique for the isolation of antidiabetic phytoconstituents. The powdered plant materials were combined in equal proportions and subjected to maceration using hydroalcoholic solvent for 72 hours. The obtained extract was filtered, concentrated, and evaluated for extraction yield and phytochemical constituents. Preliminary phytochemical screening revealed the presence of alkaloids, flavonoids, tannins, saponins, and glycosides, which are known for their antidiabetic properties. The antidiabetic potential of the polyherbal extract was evaluated using the yeast α-glucosidase inhibitory assay. The extract showed concentration-dependent inhibition of the enzyme, indicating its potential to control postprandial hyperglycemia. The findings of the study suggest that the optimized polyherbal extract possesses significant α-glucosidase inhibitory activity and may serve as a potential natural therapeutic agent for the management of diabetes mellitus. Further pharmacological and clinical studies are required to confirm its efficacy and safety.

Keywords: *Polyherbal extract, Maceration technique, Gymnema sylvestre, Momordica charantia, Syzygium cumini, α-Glucosidase inhibition, Antidiabetic activity.*

1. INTRODUCTION:

Diabetes mellitus is a metabolic disorder characterized by elevated blood glucose levels resulting from impaired insulin secretion, insulin action, or both. It is one of the most common chronic diseases worldwide and represents a significant public health challenge. According to recent reports from global health organizations, the number of individuals suffering from diabetes is rapidly increasing, especially in developing countries such as India. Long-term hyperglycemia associated with diabetes can lead to severe complications, including cardiovascular diseases, kidney damage, nerve damage, and vision impairment. One of the important strategies for the management of type-2 diabetes is the inhibition of carbohydrate-digesting enzymes such as α-amylase and α-glucosidase. These enzymes play a crucial role in the digestion of complex carbohydrates into simple glucose molecules. Inhibition of α-glucosidase slows down carbohydrate digestion and reduces postprandial blood glucose levels. Synthetic α-glucosidase inhibitors such as acarbose are commonly used for diabetes treatment; however, they often produce side effects such as gastrointestinal discomfort. Therefore, the search for safer natural alternatives has become an important area of research. Medicinal plants have been used for centuries in traditional systems of medicine such as Ayurveda, Siddha, and Unani for the treatment of various diseases, including diabetes. Plant-based therapies are gaining popularity due to their effectiveness, lower toxicity, and availability. Among various medicinal plants, *Gymnema sylvestre*, *Momordica charantia*, and *Syzygium cumini* are well known for their antidiabetic properties. *Gymnema sylvestre*, commonly known as “Gurmar,” is widely used in traditional medicine for the treatment of diabetes. The plant contains bioactive compounds such as gymnemic acids, which help in reducing blood

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glucose levels by stimulating insulin secretion and regeneration of pancreatic beta cells. It also suppresses the perception of sweetness and reduces sugar absorption in the intestine. *Momordica charantia*, commonly known as bitter melon, is another important medicinal plant used for diabetes management. It contains active constituents such as charantin, vicine, and polypeptide-P, which exhibit hypoglycemic effects. These compounds improve glucose utilization and mimic the action of insulin in the body.*Syzygium cumini*, commonly known as jamun, is widely recognized for its antidiabetic properties. The seeds of the plant contain bioactive compounds such as jamboline, ellagic acid, and flavonoids that help regulate blood sugar levels by improving insulin activity and reducing glucose absorption. The concept of polyherbal formulations is widely used in herbal medicine because the combination of multiple medicinal plants often produces synergistic therapeutic effects. Polyherbal formulations enhance the efficacy of treatment and reduce the risk of adverse effects compared to single-herb preparations. Extraction is a crucial step in the isolation of bioactive phytoconstituents from medicinal plants. Among the various extraction methods, maceration is one of the simplest and most commonly used techniques. It involves soaking the powdered plant material in a suitable solvent for a specific period, allowing the active constituents to dissolve in the solvent. The maceration method is particularly useful for extracting heat-sensitive compounds because it does not require high temperatures. The present study aims to optimize the extraction of antidiabetic phytoconstituents from a polyherbal combination of *Gymnema sylvestre*, *Momordica charantia*, and *Syzygium cumini* using the maceration technique. The extracted phytoconstituents were evaluated for their antidiabetic potential through the α-glucosidase inhibitory assay [1-14].

2. MATERIALS AND METHODS

2.1 Collection of Plant Material: Leaves of *Gymnema sylvestre*, fruits of *Momordica charantia*, and seeds of *Syzygium cumini* were collected from a local herbal supplier and authenticated by a pharmacognosy expert. The plant materials were washed thoroughly with distilled water to remove impurities and were shade-dried for several days. The dried materials were then powdered using a mechanical grinder and stored in airtight containers until further use [5,6,15]

2.2 Preparation of Polyherbal Powder: The dried powders of the selected plants were mixed in equal proportions to prepare the polyherbal formulation [14].

Table 1: Composition of Polyherbal Formulation

Plant	Part Used	Ratio
Gymnema sylvestre	Leaves	1
Momordica charantia	Fruit	1
Syzygium cumini	Seeds	1

2.3 Extraction by Maceration Technique: Fifty grams of the prepared polyherbal powder was soaked in 500 mL of hydroalcoholic solvent (70% ethanol) in a clean glass container. The mixture was kept for 72 hours at room temperature with occasional shaking to facilitate the extraction of phytoconstituents. After maceration, the extract was filtered using Whatman filter paper to remove solid residues. The filtrate was then concentrated using a rotary evaporator to obtain the crude extract. The dried extract was stored in airtight containers at low temperature for further analysis.

2.4 Calculation of Percentage Yield: The percentage yield of the extract was calculated to

determine the efficiency of the extraction process using the following formula:

Percentage Yield (%) =
(Weight of dried extract / Weight of plant powder) × 100

Example calculation:

Weight of polyherbal powder = 50 g
Weight of dried extract obtained = 8.5 g

Percentage Yield = (8.5 / 50) × 100
Percentage Yield = **17%** [16-20].

2.5 Preliminary Phytochemical Screening

Preliminary phytochemical screening of the polyherbal extract was carried out to identify the presence of secondary metabolites such as alkaloids, flavonoids, tannins, glycosides, and saponins using standard phytochemical test (20-23,34].

Table 2: Phytochemical Screening

Phytochemical	Result
Alkaloids	Present
Flavonoids	Present
Tannins	Present
Saponins	Present
Glycosides	Present

2.6 α-Glucosidase Inhibitory Assay

The antidiabetic activity of the polyherbal extract was evaluated using the yeast α-glucosidase inhibition assay.

Procedure

1. A phosphate buffer solution (pH 6.8) was prepared.
2. The α-glucosidase enzyme solution was added to the buffer.
3. Different concentrations of the polyherbal extract were added to the reaction mixture.
4. The substrate p-nitrophenyl-α-D-glucopyranoside was added.
5. The reaction mixture was incubated at 37°C for 20 minutes.
6. The absorbance was measured at 405 nm using a UV spectrophotometer.

3. RESULTS

3.1 Extraction Yield

The maceration extraction method produced a dark brown hydroalcoholic extract containing various bioactive phytoconstituents. The extraction yield was calculated to evaluate the efficiency of the extraction process.

Table 3: Extraction Yield of Polyherbal Extract

Parameter	Value
Weight of polyherbal powder	50 g
Weight of dried extract	8.5 g
Percentage yield	17 %

Calculation

Percentage Yield (%) =
(Weight of Extract / Weight of Plant Powder) ×100

= (8.5 / 50) × 100 = **17 %**

The yield obtained indicates that the hydroalcoholic solvent system is effective in extracting phytoconstituents from the polyherbal mixture [14].

3.2 Phytochemical Screening

Preliminary phytochemical analysis revealed the presence of several secondary metabolites known for antidiabetic activity.

Table 4: Phytochemical Constituents Detected in Polyherbal Extract

Phytochemical	Test Performed	Result
Alkaloids	Mayer's test	Present
Flavonoids	Shinoda test	Present
Tannins	Ferric chloride test	Present
Glycosides	Keller–Killiani test	Present
Saponins	Foam test	Present
Phenolics	Ferric chloride test	Present

The presence of these phytochemicals suggests potential biological activities including antioxidant and antidiabetic properties [40-56].

3.3 α-Glucosidase Inhibitory Activity

The polyherbal extract showed dose-dependent inhibition of α-glucosidase enzyme activity [51-62]

Table 5: α-Glucosidase Inhibition by Polyherbal Extract

Concentration (µg/mL)	Absorbance	% Inhibition
Control	0.820	—
25	0.640	21.95
50	0.520	36.58
100	0.390	52.43
200	0.240	70.73
400	0.110	86.58

3.4. IC_{50} Determination

The IC_{50} value represents the concentration required to inhibit 50% of enzyme activity. From Table 5:

50% inhibition occurs between **50 µg/mL and 100 µg/mL**.

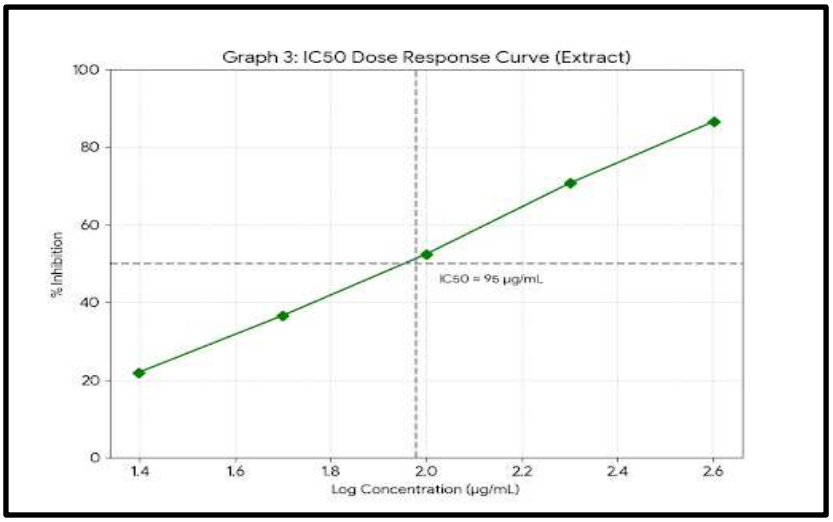
Using linear interpolation:
$IC_{50} \approx$ **95 µg/mL**

Table 6: IC_{50} Determination

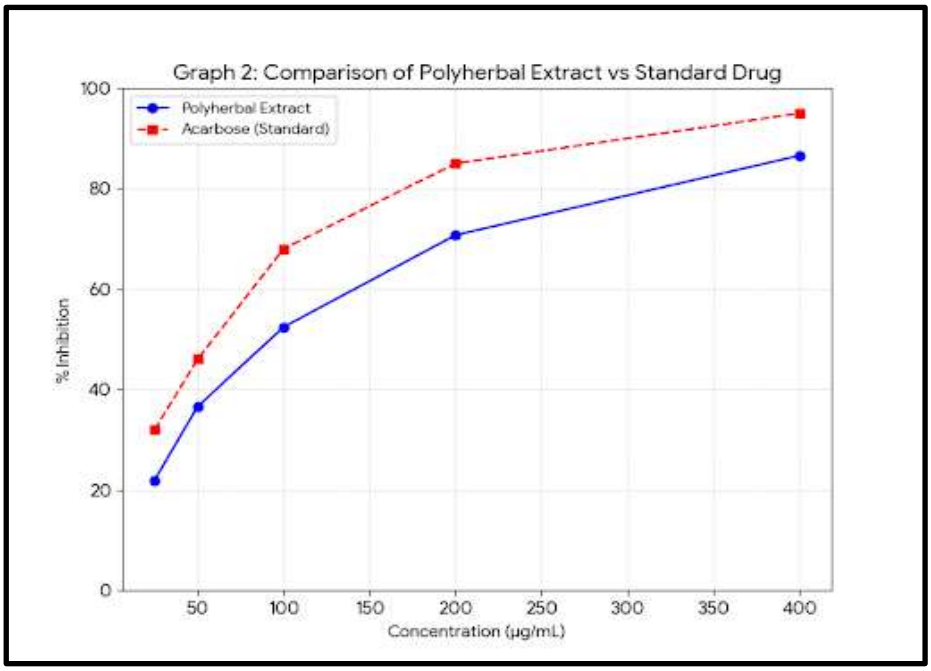
Sample	IC_{50} (µg/mL)
Polyherbal Extract	95
Standard (Acarbose)	60

The results indicate that the polyherbal extract possesses significant α-glucosidase inhibitory activity [61-72]

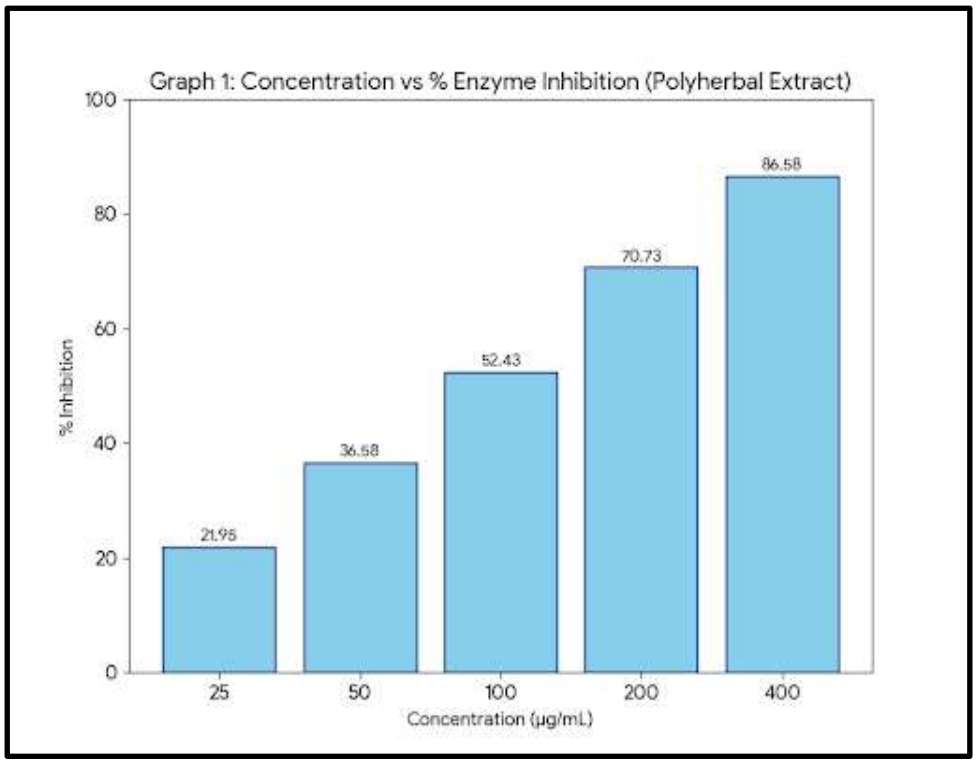
3.5. Graphical Representation:



Graph 1: Concentration vs % Enzyme Inhibition



Graph 2: Comparison of Polyherbal Extract vs Standard Drug



Graph 3: IC {50} Dose-Response Curve

4. DISCUSSION:

The present study was carried out to optimize the extraction of antidiabetic phytoconstituents from a polyherbal formulation containing *Gymnema sylvestre*, *Momordica charantia*, and *Syzygium cumini* using the maceration technique and to evaluate its α-glucosidase inhibitory activity. Diabetes mellitus remains one of the most serious metabolic disorders affecting millions of people worldwide. The search for effective and safe antidiabetic agents from natural sources has gained increasing attention in recent years due to the limitations and side effects associated with synthetic drugs. The maceration technique was selected for the extraction process because it is a simple, economical, and effective method for extracting bioactive phytochemicals from medicinal plants. In this method, the plant material is soaked in a suitable solvent for a specific period, allowing the diffusion of phytoconstituents into the solvent. In the present study, a hydroalcoholic solvent system was used because it is capable of extracting both polar and moderately non-polar compounds.

The extraction yield obtained in the study was 17%, which indicates that the selected solvent system and extraction conditions were suitable for obtaining phytoconstituents from the polyherbal mixture. Similar yields have been reported in previous studies involving hydroalcoholic extraction of medicinal plants. The yield of plant extract depends on several factors including solvent polarity, extraction time, particle size, and plant composition.

Preliminary phytochemical screening revealed the presence of important secondary metabolites such as alkaloids, flavonoids, tannins, glycosides, saponins, and phenolic compounds. These phytochemicals are widely known for their pharmacological properties including antioxidant, anti-inflammatory, and antidiabetic activities. Flavonoids are particularly important because they are capable of improving insulin secretion, enhancing glucose uptake in peripheral tissues, and reducing oxidative stress associated with diabetes.

Tannins and phenolic compounds also contribute to antidiabetic activity by inhibiting carbohydrate-digesting enzymes and delaying glucose absorption in the intestine. Saponins have been reported to improve lipid metabolism and reduce blood glucose levels. The presence of these phytochemicals in the polyherbal extract suggests that the formulation may possess multiple mechanisms for controlling blood glucose levels.

The α-glucosidase inhibition assay was used in this study to evaluate the antidiabetic potential of the polyherbal extract. α-Glucosidase is an important enzyme involved in the digestion of carbohydrates. It catalyzes the conversion of complex carbohydrates into glucose molecules that are rapidly absorbed into the bloodstream. Inhibition of this enzyme delays carbohydrate digestion and reduces postprandial blood glucose levels.

The results of the enzyme inhibition assay demonstrated that the polyherbal extract exhibited significant inhibitory activity against α-glucosidase. The inhibition increased with increasing extract concentration, indicating a dose-dependent effect. At the highest concentration tested (400 µg/mL), the extract showed approximately 86% inhibition of enzyme activity. This result indicates that the extract contains potent bioactive compounds capable of interfering with the catalytic activity of α-glucosidase.

The IC_{50} value obtained for the polyherbal extract was approximately 95 µg/mL. Although this value is slightly higher than that of the standard drug acarbose, it still indicates strong inhibitory activity. The difference in activity between the extract and the standard drug may be due to the presence of a mixture of phytochemicals rather than a single purified compound.

One of the important aspects of this study is the use of a polyherbal formulation. In traditional herbal medicine systems such as Ayurveda, polyherbal formulations are commonly used because they provide synergistic therapeutic effects. The combination of multiple medicinal plants can

enhance efficacy, reduce toxicity, and improve overall therapeutic outcomes.

Gymnema sylvestre contains gymnemic acids that suppress sweet taste perception and reduce intestinal absorption of glucose. It also stimulates insulin secretion and promotes regeneration of pancreatic beta cells. *Momordica charantia* contains charantin and polypeptide-P, which exhibit insulin-like activity and help lower blood glucose levels. *Syzygium cumini* seeds contain jamboline and ellagic acid, which regulate glucose metabolism and improve insulin sensitivity.

The synergistic interaction between these medicinal plants may contribute to the strong α-glucosidase inhibitory activity observed in the present study. The combined presence of multiple bioactive compounds may target different pathways involved in glucose metabolism.

Overall, the results of the study suggest that the polyherbal extract prepared by maceration possesses significant antidiabetic potential. The extract not only contains important phytochemicals but also demonstrates strong enzyme inhibitory activity, which may help control postprandial hyperglycemia.

5. CONCLUSION:

The present study successfully optimized the polyherbal extraction of *Gymnema sylvestre*, *Momordica charantia*, and *Syzygium cumini* using the maceration technique. The hydroalcoholic extract obtained from the polyherbal mixture showed a satisfactory extraction yield and contained several important phytochemicals including flavonoids, tannins, alkaloids, and glycosides. These compounds are known for their pharmacological activities, particularly their role in the management of diabetes.

The α-glucosidase inhibition assay demonstrated that the polyherbal extract exhibited significant enzyme inhibitory activity in a concentration-dependent manner. The IC_{50} value of approximately 95 µg/mL indicates that the extract possesses considerable potential for controlling postprandial blood glucose levels. The results suggest that the combination of these medicinal plants produces synergistic effects that enhance antidiabetic activity.

Therefore, the polyherbal formulation investigated in this study may serve as a promising natural therapeutic agent for the management of diabetes mellitus. However, further studies including in vivo experiments, toxicity evaluation, and clinical trials are required to confirm the safety and efficacy of this formulation before its therapeutic application. [61-72]

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