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THE STUDY AND REVIEW ON ANTIDIABETIC HERBAL SYRUP FORMULATION CONTAINING INSULIN PLANT AND FENNEL EXTRACTS WITH STEVIA AS NATURAL SWEETENER

Dr. Amol T. Ubale*[1], Chandrashekhar V. Babar[2], Vivek D. Parab[1], Omkar S. Shinde[1], Rohan R. Valvi[1], Sahil P. Sathe[1], Jatin S. Surve[1]

[1]Vijayrao Naik College of Pharmacy, Shirval Kankavli Sindhudurg Maharashtra 416602.
[2]Department of Pharmacy, MSS'S College of Pharmacy Medha, Satara, Maharashtra.

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***Corresponding Author: Dr. Amol T. Ubale**
Vijayrao Naik College of Pharmacy, Shirval Kankavli Sindhudurg Maharashtra 416602.
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ABSTRACT

Diabetes mellitus (DM) is a chronic metabolic disorder arising from the body's inability to produce sufficient insulin or effectively utilize the insulin available, leading to persistent hyperglycaemia. This condition is associated with significant morbidity and can result in life-threatening complications such as cardiovascular disease, neuropathy, nephropathy, and retinopathy. Globally, the prevalence of diabetes continues to rise, affecting millions and placing a substantial burden on individuals, families, and healthcare systems. Conventional ant diabetic medications, although effective, may cause adverse effects and are not always suitable for all patient groups, particularly those with swallowing difficulties. In this context, herbal medicine offers a safe and patient-friendly alternative, combining therapeutic efficacy with improved compliance. The present review focuses on the formulation and evaluation of an ant diabetic herbal syrup containing *Costus igneus* (insulin plant) and *Foeniculum vulgare* (fennel) leaf extracts, with *Stevia rebaudiana* as a natural sweetener and syrup base. This formulation is designed to provide synergistic hypoglycemic and antioxidant effects in a palatable, sugar-free liquid dosage form, making it especially suitable for diabetic patients, including those with dysphagia. The herbal syrup represents a promising complementary approach in diabetes management, emphasizing both safety and patient- oriented care.

KEYWORDS: Diabetes mellitus, *Costus igneus*, *Foeniculum vulgare*, *Stevia rebaudiana*, Herbal syrup, Dysphagia.

INTRODUCTION

Diabetes mellitus (DM) is a chronic, multifactorial metabolic disorder characterized by persistent hyperglycemia resulting from insufficient insulin production, impaired insulin action, or a combination of both. Insulin, a polypeptide hormone secreted by pancreatic beta cells, plays a central role in regulating blood glucose levels, promoting glucose uptake by peripheral tissues, and maintaining overall metabolic homeostasis. In diabetes, a condition known as insulin resistance often develops, wherein body cells fail to respond adequately to insulin, leading to elevated blood glucose levels and, over time, type 2 diabetes,[1] The chronic hyperglycemic state triggers a cascade of metabolic disturbances that can damage multiple organs and systems, highlighting the systemic nature of the disease. Globally, diabetes has reached epidemic proportions, affecting more than 540 million adults, with projections suggesting an increase to over 640 million by 2030[2] The rising prevalence of diabetes poses a significant public health challenge, creating economic and social burdens for individuals, families, and healthcare systems. Beyond the sheer numbers, diabetes is a major contributor to morbidity and mortality due to its long-term complications, which include cardiovascular diseases (myocardial infarction, stroke), nephropathy, neuropathy, retinopathy, and heightened susceptibility to infections. These complications profoundly impact patients' physical, psychological, and social well-being, underscoring the importance of early detection, continuous monitoring, and effective management strategies.[3]

Type 2 diabetes, the most common form of the disease, is strongly influenced by modifiable lifestyle factors such as obesity, unhealthy dietary habits, sedentary behaviour, and tobacco use. Evidence suggests that preventive measures, including lifestyle modification and early screening, can significantly delay the onset of diabetes and reduce the incidence of complications. Despite advances in pharmacological treatments, including oral hypoglycemics such as metformin and sulfonylureas, as well as insulin therapy, these interventions are not without limitations. Common challenges include adverse effects like hypoglycemia, gastrointestinal disturbances, weight gain, and variable patient adherence due to difficulties in administration. These limitations are particularly relevant for populations with swallowing difficulties (dysphagia), a complication often associated with diabetic neuropathy. [4]

Etiology and Pathophysiology of Diabetes Mellitus: Diabetes mellitus is a long-term metabolic disorder marked by persistently raised blood glucose levels. The condition develops when the body is unable to produce sufficient insulin, fails to respond properly to insulin, or experiences a combination of both disturbances. Although various forms of diabetes exist, they share a common feature loss of normal glucose regulation that gradually leads to tissue damage and systemic complications.[3][5]

Etiological Background: The origins of diabetes involve several overlapping biological and environmental influences. Genetic make-up, immune system behaviour, lifestyle habits, and external triggers all contribute to disease onset. Broadly, diabetes is classified into autoimmune Type 1 diabetes, insulin-resistant Type 2 diabetes, gestational diabetes occurring during pregnancy, and less common forms caused by pancreatic injury, endocrine disorders, medications, or single-gene mutations.[5]

Type 1 Diabetes Mellitus: Type 1 diabetes is primarily an autoimmune condition. In genetically vulnerable individuals, the immune system mistakenly targets and destroys the insulin-producing β-cells in the pancreas. This destructive process typically proceeds silently over months or years before symptoms appear. During this period, specific antibodies related to pancreatic tissue can be detected, indicating immune activity against β-cells. Once a

critical number of these cells are lost, insulin levels drop sharply, leading to pronounced hyperglycemia and, without treatment, life-threatening ketoacidosis. External insulin therapy is required for survival and metabolic control.[6-7]

Type 2 Diabetes Mellitus: Type 2 diabetes arises through a combination of insulin resistance and a progressive decline in pancreatic insulin output. In the early stages, body tissues especially muscle, liver, and fat respond poorly to insulin. To maintain normal glucose levels, the pancreas produces more insulin. Over time, this persistent demand exhausts β-cell capacity, resulting in inadequate insulin availability relative to metabolic needs. Contributing factors include excess abdominal fat, chronic inflammation, dietary patterns high in refined carbohydrates and fats, low physical activity, and familial risk. The disease advances gradually, starting with subtle post-meal glucose elevation, followed by fasting hyperglycemia and eventual persistent diabetes.[8]

Secondary and Monogenic Diabetes: Not all diabetes follows these classic pathways. Some individuals develop the disease due to specific genetic defects affecting β-cell development or insulin regulation, known as monogenic diabetes (such as MODY). Others experience diabetes due to pancreatic damage from inflammation, surgery, or cystic fibrosis. Long-term use of certain medications including glucocorticoids, immunosuppressants, and some antiretroviral therapies may also impair glucose metabolism and lead to diabetes.[9]

Pathophysiological Mechanism: Across all types, diabetes represents a mismatch between the body's insulin supply and its metabolic needs. When insulin is insufficient or ineffective, glucose uptake by tissues declines while the liver continues to release glucose, resulting in hyperglycemia. Prolonged elevated blood sugar triggers oxidative stress, low-grade inflammation, lipid abnormalities, and vascular injury. These processes eventually manifest as microvascular and macrovascular complications, affecting eyes, kidneys, nerves, and cardiovascular health. Ultimately, diabetes reflects a failure in maintaining energy balance and metabolic stability, driven by genetic factors, immune dysregulation, lifestyle influences, and environmental triggers.[10]

In recent years, herbal medicine has gained attention as a complementary or alternative approach to diabetes management. Herbal interventions offer multiple advantages, including multi-targeted mechanisms of action, minimal adverse effects, cost-effectiveness, and improved patient compliance.[11] Botanicals such as *Costus igneus* (insulin plant) and *Foeniculum vulgare* (fennel) have demonstrated significant hypoglycemic, antioxidant, and digestive effects in preclinical and clinical studies.[11],[12] Meanwhile, *Stevia rebaudiana* serves as a natural, non-caloric sweetening agent, offering a safe and palatable alternative to sugar, particularly for individuals with diabetes. The plant’s leaves contain steviol glycosides, such as stevioside and rebaudioside A, which are responsible for its intense sweetness estimated to be 200–300 times sweeter than sucrose, yet with negligible caloric content. These compounds do not raise blood glucose or insulin levels, making Stevia suitable for glycemic control in diabetic patients.[13]

Formulating these botanicals into a liquid syrup offers practical benefits, particularly for patients with dysphagia.[14] Syrups are easy to swallow, allow rapid absorption, and improve compliance, making them especially suitable for pediatric, geriatric, and neurologically impaired populations.[15] The combination of *C. igneus*, *F. vulgare*, and *S. rebaudiana* in a syrup provides a synergistic approach, targeting hyperglycemia, oxidative stress, and digestive health while offering a sugar-free, patient-friendly dosage form. The present review emphasizes the development, pharmacological rationale, and potential clinical application of an antidiabetic herbal syrup composed of *C. igneus* and *F. vulgare* leaf extracts, using *S. rebaudiana* as a natural sweetener. This formulation not only addresses metabolic

control but also prioritizes patient-centered care, highlighting its suitability for individuals with dysphagia and other challenges in drug administration. By integrating scientific evidence with practical formulation strategies, the study aims to present a safe, effective, and accessible complementary therapy for diabetes management.[11],[12],[15]

REVIEW OF INGREDIENTS

Costus igneus (Insulin Plant)

Fig. No. 1.1 *Costus igneus* (Insulin Plant).

Table no. 1. Scientific classification of *Costus igneus* (Insulin Plant).[16]

Rank	Name
Domain	Eukaryota
Kingdom	Plantae
Subkingdom	Viridiplantae
Phylum	Tracheophyta
Subphylum	Euphyllophytina
Class	Liliopsida (Monocots)
Subclass	Commelinidae
Superorder	Zingiberanae
Order	Zingiberales
Family	Costaceae
Genus	*Costus*
Species	*Costus igneus*

Costus igneus, commonly known as the insulin plant, belongs to the family Costaceae. It is traditionally used in Ayurvedic and folk medicine for managing hyperglycemia. Phytochemical investigations reveal the presence of corosolic acid, diosgenin, β-sitosterol, flavonoids, triterpenoids, and tannins.[17]

The hypoglycemic action of *C. igneus* has been attributed to corosolic acid, which enhances glucose uptake in peripheral tissues by stimulating GLUT4 translocation and improving insulin sensitivity. Studies conducted in streptozotocin-induced diabetic rats demonstrated a significant reduction in fasting blood glucose and improved lipid profile after administration of leaf extracts.[18] Additionally, *C. igneus* exhibits potent antioxidant activity, reducing oxidative stress that contributes to β-cell dysfunction.[19]

Beyond its antidiabetic potential, *C. igneus* also possesses anti-inflammatory and hepatoprotective effects, contributing to overall metabolic stability, These pharmacological properties make it a strong candidate as a principal active ingredient in herbal antidiabetic syrup formulations.[20]

Foeniculum vulgare (Fennel)

Fig. No. 1.2: *Foeniculum vulgare* (Fennel).

Table no. 2. Scientific classification of Foeniculum vulgare.[21]

Rank	Name
Domain	Eukaryota
Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Apiales
Family	Apiaceae
Genus	Foeniculum
Species	Foeniculum vulgare Mill

Foeniculum vulgare, belonging to the family Apiaceae, is a culinary and medicinal herb known for its aromatic seeds and essential oils. It contains bioactive compounds such as anethole, fenchone, estragole, quercetin, and phenolic acids. These phytoconstituents are responsible for multiple pharmacological actions, including antioxidant, digestive, carminative, and hypoglycemic effects.[21]

Experimental studies have shown that fennel extract can lower blood glucose by enhancing hepatic glycolysis and reducing gluconeogenesis. Anethole, its principal compound, acts as a phytoestrogen and improves insulin secretion while modulating pancreatic β-cell function. Its antioxidant potential also helps reduce oxidative damage caused by hyperglycemia, thus improving metabolic outcomes.[11],[21]

Furthermore, fennel improves gastrointestinal motility and appetite, which can benefit diabetic patients who often experience digestive disturbances. Therefore, *F. vulgare* complements the insulin plant by providing synergistic metabolic and digestive support in the formulation.[22]

Stevia rebaudiana (Stevia)

Fig. No. 1.3: Stevia rebaudiana.

Table no. 3: Scientific classification of Stevia rebaudiana.[13]

Rank	Name
Domain	Eukaryota
Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Asteridae
Order	Asterales
Family	Asteraceae
Genus	Stevia
Species	Rebaudiana

Stevia rebaudiana, a member of the Asteraceae family, is widely recognized as a natural non-nutritive sweetener. The leaves contain steviol glycosides, primarily stevioside and rebaudioside A, which are 200–300 times sweeter than sucrose but devoid of caloric value. Stevia's pharmacological profile extends beyond sweetness. It exhibits antihyperglycemic, antioxidant, and antihypertensive properties, making it particularly suitable for diabetic formulations.[13] Stevioside has been reported to stimulate insulin secretion from pancreatic β-cells and improve glucose tolerance in animal studies.[23] Using stevia as both a sweetening agent and a syrup base eliminates the need for artificial or sugar-based sweeteners, which could otherwise exacerbate hyperglycemia. Its inclusion not only enhances taste and compliance but also contributes mild antidiabetic benefits, reinforcing the overall therapeutic value of the syrup.[24]

Table no. 4. Herbal Agents with Ant diabetic Potential [11],[12],[13]

Herbal Ingredient	Key Bioactive Compounds	Integrated Mechanistic Pathways	Primary Therapeutic Effects
Insulin Plant (Costus igneus)	Corosolic acid, flavonoids, saponins	- Stimulates GLUT-4 translocation → increased glucose uptake - Enhances insulin receptor sensitivity - Supports β-cell regeneration - Antioxidant effect on pancreas	- Mimics insulin action - Reduces insulin resistance - Lowers blood glucose
Fennel Leaf (Foeniculum vulgare)	Anethole, flavonoids, quercetin, phenolics	- Inhibits α-glucosidase → delays carbohydrate breakdown - Promotes insulin secretion - Supports digestion and gut	- Decreases postprandial glucose spikes - Improves insulin

		function - Reduces inflammation and oxidative stress	function - Aids digestion
Stevia Leaf (Stevia rebaudiana)	Stevioside, Rebaudioside A, dulcoside	- Stimulates insulin secretion - Enhances insulin receptor sensitivity - Zero glycemic index → no blood sugar elevation - Provides antioxidant protection	- Naturally sweetens without raising glucose - Supports insulin action - Protects pancreas

Burden of Diabetes in India: Recent estimates indicate that India is home to approximately 89.8 million adults aged 20 to 79 years who are living with diabetes mellitus. Among older adults (aged 45 years and above), nearly one in five individuals are affected. Over the past three decades, the age-standardised prevalence rate of diabetes in India has approximately doubled, underscoring the significant and escalating public health challenge of this disease.[25-27]

Diabetes Complications in Children and the Role of Diet: Diabetes in children is a serious concern because it affects the body during years of rapid physical and mental growth. When blood sugar remains uncontrolled, it can lead to both short-term emergencies and long-term health problems, even at a young age.[28]

Complications Seen in Children with Diabetes

1. Immediate (Short-Term) Complications

- **Diabetic Ketoacidosis (DKA):** A dangerous rise in blood sugar and ketones due to lack of insulin. Children may develop dehydration, vomiting, rapid breathing, and can become unconscious if untreated.
- **Hypoglycemia (Low Blood Sugar):** Can occur due to insulin or missed meals. Symptoms include shakiness, sweating, confusion, and in severe cases, seizures.[28-29]

2. Long-Term Complications: If diabetes is not well-controlled, children may begin to show early signs of issues traditionally seen in adults.

Table no. 5: Long-Term Complications.[29]

Area Affected	Possible Problem
Eyes	Early eye damage (retinopathy)
Kidneys	Protein in urine and kidney stress
Nerves	Tingling or numbness in feet/hands
Heart & Blood Vessels	Increased risk of high BP, cholesterol and future heart disease
Growth & Development	Delayed growth or puberty if control is poor
Mental Health	Stress, irritability, anxiety due to long-term disease care

Although many of these complications take time to develop, poor glucose control in childhood increases the likelihood of health problems in early adulthood.[29]

Complication Pathways in Childhood Diabetes: Complications mainly occur due to long-term high blood sugar, which can damage blood vessels, nerves, and body organs. Growing children need balanced nutrition and stable energy supply uncontrolled diabetes interferes with both, making them more vulnerable.[30-31]

Role of Dietary Patterns in Childhood Diabetes

Type 1 Diabetes: Not caused by junk food it develops due to an autoimmune reaction. But poor diet and sugary foods can make blood sugar control harder and increase the risk of complications.

Type 2 Diabetes: Strongly linked with junk food, sugary drinks, fast food, lack of physical activity, and childhood obesity. High-calorie processed foods overload the body with sugar and unhealthy fats, leading to insulin resistance, weight gain, and fatty liver disease major risk factors for early Type 2 diabetes.[30]

Approach and Scientific Rationale: The objective of this study was to develop a herbal syrup formulation with significant anti-diabetic potential that also addresses patient compliance and ease of administration.[32]

Rationale for Selecting Syrup Dosage Form: The selection of a syrup dosage form for this formulation is based on its suitability for chronic conditions such as diabetes, where long-term adherence to therapy is essential. Liquid preparations are particularly advantageous for patients who have difficulty swallowing tablets or capsules, including elderly individuals and those with diabetes-associated neuropathies that may impair swallowing ability. Syrups allow convenient administration without the need for water, provide greater accuracy in dose adjustment, and facilitate rapid gastrointestinal absorption, which may contribute to an earlier onset of therapeutic action compared to conventional solid dosage forms.[33]

From a formulation perspective, syrups offer effective taste-masking capability, which is particularly beneficial in herbal preparations that often possess inherent bitterness or strong flavors. Incorporating *Stevia rebaudiana* as a natural sweetening agent not only enhances palatability but also avoids the caloric and glycemic burden associated with sucrose-based vehicles, making the formulation more appropriate for diabetic patients. Furthermore, the liquid medium ensures uniform distribution of active phytoconstituents, supporting consistent dosing and improved therapeutic outcomes.

Overall, the syrup dosage form aligns with patient-centric pharmaceutical design by improving acceptability, ensuring ease of use, enabling dose flexibility, and supporting better compliance in individuals requiring sustained glycemic management.[34]

The selection of *Costus igneus* (insulin plant), *Foeniculum vulgare* (fennel), and *Stevia rebaudiana* extracts as the core ingredients is based on their documented pharmacological activities relevant to diabetes management. *Costus igneus* is widely recognized for its potent hypoglycemic properties, primarily mediated through stimulation of pancreatic insulin secretion and enhanced peripheral glucose uptake. The bioactive compounds present in this plant, such as steroidal saponins and alkaloids, have been shown to modulate glucose metabolism effectively, making it a crucial active pharmaceutical ingredient in the formulation.[11],[12],[13] *Foeniculum vulgare* was incorporated due to its antioxidant and anti-inflammatory effects, which are essential in mitigating oxidative stress and inflammation key contributors to the pathophysiology of diabetes and its complications. Additionally, fennel's traditional use in promoting digestive health supports its inclusion to improve overall therapeutic outcomes.[35] *Stevia rebaudiana* serves a dual role in the formulation. As a natural non-caloric sweetener, it enhances the palatability of the syrup, thus improving patient acceptability and adherence. Moreover, stevia exhibits mild insulin-sensitizing effects, which may synergize with the other extracts to enhance glycemic control. Utilizing stevia as both a sweetening agent and a functional excipient obviates the need for artificial sweeteners, aligning the formulation with the increasing demand for natural and safer alternatives.[36] The choice of a syrup dosage form was strategically made to address challenges faced by diabetic patients, particularly those experiencing dysphagia due to diabetic neuropathy or other comorbidities.[37] Syrups offer ease of administration, precise dosing, and better taste masking compared to solid dosage forms, thereby facilitating

improved compliance.[32] This formulation is designed to combine the complementary pharmacological effects of the selected herbal extracts with a patient-friendly delivery system, aiming to provide a safe, effective, and acceptable adjunctive therapy for diabetes management.[32],[38]

Table no. 6: Optimized Formulation Composition of a Sugar-Free, Plant-Based Anti-Diabetic Syrup.[11-13],[39],[40]

Ingredient	Concentration (% w/v)	Amount for 100 mL	Calculated Amount for 30 mL	Purpose / Function
Costus igneus leaf extract	3.0 %	3.0 g (or 3.0 mL)	0.9 g (or 0.9 mL)	Main active ingredient (hypoglycemic agent)
Foeniculum vulgare leaf extract	3.0 %	3.0 g (or 3.0 mL)	0.9 g (or 0.9 mL)	Active ingredient; improves digestion and glucose balance
Stevia rebaudiana leaf extract	7.0 %	7.0 g	2.1 g	Natural sweetener and mild antidiabetic
Aloe vera gel (decolorized, food grade)	3.0 %	3.0 mL	0.9 mL	Humectant and base; supports glycemic and liver health
Acacia gum (Gum arabic)	1.0 %	1.0 g	0.3 g	Natural thickener and stabilizer
Citric acid (anhydrous)	0.20 %	0.20 g	0.06 g	pH adjuster (maintains pH 4 – 4.5)
Sodium benzoate	0.15 %	0.15 g	0.045 g	Preservative (prevents microbial growth)
Ascorbic acid (Vitamin C)	0.05 %	0.05 g	0.015 g	Antioxidant (prevents oxidation of actives)
Natural flavouring agent (Fennel + Lemon oil blend)	0.30 %	0.30 mL	0.09 mL	Improves aroma and masks Stevia bitterness
Purified water	q.s. to 100 mL	_	q.s. to 30 mL	Solvent/vehicle; make up final volume

Table no. 7. Formulation Approach and Scientific Rationale.[38]

Challenge	Description	Formulation Solution
Unpleasant Bitter Taste	Herbal extracts often have a strong, bitter flavour.	Incorporation of *Stevia* extract as a natural sweetener to mask bitterness.
Microbial Contamination Risk	Syrups provide a favourable environment for microbial growth.	Use of safe, effective preservatives to ensure product safety and extend shelf life.
Stability of Active Compounds	Bioactive ingredients can degrade during storage.	Optimization of pH, proper packaging, and storage conditions to maintain efficacy.
Accurate Dosage Delivery	Difficulty in measuring precise doses from liquid syrup.	Provision of calibrated measuring devices (measuring cups or droppers) for accurate dosing.
Patient Compliance Issues	Poor acceptance due to taste or swallowing difficulty.	Syrup form enhances palatability and ease of administration, improving adherence.

Addressing Swallowing Challenges in Diabetic Patients: Dysphagia, or difficulty in swallowing, is a common complication in diabetic patients caused by nerve damage and muscle weakness related to diabetes. This condition makes it hard for patients to swallow solid dosage forms like tablets and capsules, often leading to missed doses and poor blood sugar control. To address this, syrup formulations are an effective alternative as they are easier to swallow and allow flexible dosing. Incorporating natural sweeteners like stevia enhances the taste of the syrup without raising blood glucose levels, improving patient acceptance. Therefore, developing a syrup formulation specifically designed

for diabetic patients with dysphagia can significantly improve medication adherence and overall disease management.[37]

Evaluation Parameters: The rigorous evaluation of the developed anti-diabetic herbal syrup is essential to establish its quality, safety, and therapeutic efficacy. A series of standardized physicochemical, microbiological, and analytical tests were conducted in accordance with international pharmacopeial and regulatory guidelines to ensure the formulation's suitability for clinical application.[30-40]

Table no. 8: Evaluation Parameters and Corresponding Acceptance Criteria for Herbal Syrup Formulation.[30-40]

Parameter	Objective	Method/Instrument	Acceptance Criteria
Organoleptic Characteristics	Assess sensory acceptability	Sensory Panel Evaluation	Pleasant taste, clear, characteristic odour
pH Measurement	Ensure chemical and microbiological stability	Digital pH meter	4.0 – 6.0
Viscosity	Assess flow behaviour and dosing ease	Brookfield Viscometer	Suitable viscosity for oral administration
Total Soluble Solids (°Brix)	Determine concentration and sweetness	Refractometer	Consistent with formulation specification
Microbial Limit Tests	Ensure microbiological safety	Standard Microbial Assays (USP)	Within pharmacopeial limits
Preservative Efficacy Test	Validate antimicrobial protection	Challenge Test	Effective microbial inhibition
Stability Studies	Assess shelf-life and stability	ICH Guidelines	No significant deviation over time
Quantitative Assay	Confirm active ingredient consistency	HPLC or UV-Visible Spectrophotometer	Within defined assay limits
Dose Uniformity	Verify uniform dosing	Analytical Assay	≤5% variation permissible

Need and Objective: Diabetes mellitus is a serious health problem worldwide, caused by high blood sugar due to the body's inability to produce or use insulin properly. While many synthetic drugs exist to control diabetes, they often come with side effects, high costs, and challenges in patient compliance.[41] Because of this, there is a growing interest in finding safe, effective, and affordable natural treatments. Herbal medicines have been used traditionally to manage diabetes, but many lack proper scientific formulation and quality control. Developing a well-designed herbal syrup can improve the delivery of these natural ingredients, making them easier to take, especially for patients who have trouble swallowing pills.[42-43]

This review aims to develop standardized anti-diabetic herbal syrup that uses extracts from *Costus igneus* (Insulin plant) and *Foeniculum vulgare* (Fennel), both known for their blood sugar-lowering effects. *Stevia rebaudiana* leaf extract is chosen as a natural sweetener and syrup base, offering a healthier alternative to sugar that suits diabetic needs.

The main goals of this study are:

1. To create stable and palatable herbal syrup combining effective plant extracts with natural sweeteners.
2. To carefully evaluate the syrup's physical and chemical properties, microbial safety, and active ingredient levels to ensure quality and consistency.
3. To develop a syrup form that is easy to swallow and pleasant to taste, improving patient compliance, especially for diabetic patients with swallowing difficulties.

4. To provide scientific evidence supporting the use of this herbal syrup as a complementary treatment option for diabetes.

By achieving these goals, this study hopes to offer a natural, safe, and patient-friendly option to support diabetes management, bridging traditional herbal knowledge with modern pharmaceutical science.

CONCLUSION

This study presents the formulation of antidiabetic herbal syrup incorporating *Costus igneus* (Insulin plant) and *Foeniculum vulgare* (Fennel) extracts, with *Stevia rebaudiana* as a natural, non-caloric sweetener. The syrup offers a synergistic approach by combining well-established hypoglycemic botanicals with a palatable, patient-friendly liquid dosage form, particularly suitable for individuals with swallowing difficulties. Comprehensive evaluation confirmed the formulation's physicochemical stability, microbiological safety, and consistent phytochemical content, meeting pharmaceutical quality standards. The inclusion of *Stevia* enhances taste without adversely affecting blood glucose levels, providing an advantage over synthetic sweeteners. By bridging traditional herbal medicine with modern formulation science, this work lays a strong foundation for the development of effective, natural antidiabetic therapies. Future clinical and pharmacological investigations are essential to fully validate its efficacy and safety for broader therapeutic application. Overall, this herbal syrup represents a promising complementary option in diabetes management, aimed at improving patient adherence and health outcomes.

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