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Review

A Review Paper on Comparative in-vitro Diabetic Activity of Bitter Melon and Jamun in Diabetes Mellitus

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ABSTRACT:

Diabetes mellitus encompasses a group of endocrine disorders marked by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Type 1 diabetes arises from autoimmune destruction of pancreatic β-cells, leading to absolute insulin deficiency, while Type 2 diabetes, accounting for over 90% of cases, involves insulin resistance coupled with relative insulin deficiency. Gestational diabetes and other specific types further diversify the spectrum. The International Diabetes Federation estimates over 500 million adults worldwide affected in 2021, with projections exceeding 700 million by 2045, driven by urbanization, sedentary lifestyles, and dietary shifts. Pathophysiologically, chronic hyperglycemia induces oxidative stress, inflammation, and advanced glycation end-products, culminating in microvascular complications like retinopathy, nephropathy, and neuropathy, alongside macrovascular issues such as cardiovascular disease and stroke. Insulin resistance in peripheral tissues, particularly skeletal muscle and adipose, impairs glucose uptake via reduced GLUT4 translocation, while hepatic gluconeogenesis escalates unabated. β-cell dysfunction progresses, with amyloid deposition and lipotoxicity exacerbating insulin secretory failure. In vitro models, including insulin-resistant myotubes, hepatocyte cell lines, and adipocyte cultures, replicate these mechanisms, enabling precise evaluation of antidiabetic agents without systemic variables.

KEYWORD: *diabetes mellitus, bitter melon, insulin, glucose*

1. INTRODUCTION

Diabetes mellitus refers to a multifaceted group of metabolic conditions defined by chronic hyperglycemia, occurring from impairments in insulin production, its physiological activity, or a combination of both. Type 1 diabetes typically results from the autoimmune-mediated destruction of pancreatic beta-cells, leading to an absolute lack of insulin. Conversely, Type 2 diabetes—comprising over 90% of global cases—is characterized by cellular insulin resistance paired with a relative decline in insulin output. The clinical landscape is further expanded by gestational diabetes and other secondary types. In 2021, the International Diabetes Federation reported that over 500 million adults were living with the disease, with projections climbing to 700 million by 2045 due to rapid urbanization, sedentary habits, and nutritional transitions.

From a pathophysiological standpoint, persistent hyperglycemia triggers oxidative stress, systemic inflammation, and the accumulation of advanced glycation end-products. These processes drive microvascular complications, such as retinopathy, nephropathy, and neuropathy, alongside macrovascular threats like stroke and cardiovascular disease. In peripheral tissues—specifically adipose and skeletal muscle—insulin resistance prevents effective glucose absorption by hindering GLUT4 translocation, while the liver continues excessive gluconeogenesis. As β-cell exhaustion worsens, amyloid buildup and lipotoxicity further diminish insulin secretion. Modern research utilizes in vitro models, such as insulin-resistant myotubes and hepatocyte lines, to simulate these metabolic failures, allowing for the precise testing of potential treatments in a controlled environment. [1]

The global financial strain of diabetes now rivals the combined costs of cancer and HIV/AIDS, emphasizing the urgent need for therapeutic innovation beyond traditional synthetic drugs like sulfonylureas or metformin. While effective, these pharmaceuticals often carry risks of chronic complications, gastrointestinal distress, and hypoglycemia. Natural products

derived from traditional medicine offer a viable alternative, utilizing plant-based bioactive compounds to regulate glucose levels, restore insulin sensitivity, and counter oxidative damage. This research focuses on Jamun and bitter melon, two ethnobotanically significant plants, utilizing standardized in vitro assays to determine their relative therapeutic strength. [2]

1.2 Traditional Context and Ethnopharmacology

Syzygium cumini, commonly known as Jamun, is native to tropical regions of Asia and Australia. For centuries, its seeds, bark, and fruit have been core components of Ayurveda and Unani medicine. Historical texts, including the *Charaka Samhita*, define Jamun as "madhumehahara," meaning it "destroys honey urine"—a classical term for diabetes. Traditional use involves consuming seed powders or fruit decoctions to stabilize blood sugar. Similarly, Bitter melon (*Momordica charantia*), or "karela," holds a prominent place in Chinese and Ayurvedic medicine for treating "prameha" (diabetes-like symptoms). Communities in Africa and the Caribbean also consume it raw or cooked for its medicinal bitterness.

While folklore has long validated these plants through observational success—such as improved wound healing and reduced polyuria—detailed mechanistic data was scarce until modern pharmacology identified their active phytochemicals. Jamun seeds work primarily by inhibiting α-glucosidase to slow sugar digestion, while bitter melon contains charantin, which acts as a structural mimic of insulin. Despite the fact that 60% of Indian diabetics utilize herbal supplements, a rigorous scientific comparison of these two plants is still lacking. This research aims to bridge the gap between traditional ethnobotany and evidence-based clinical validation. [3]

1.3 Phytochemical and Mechanistic Comparison

The therapeutic potential of Jamun is driven by its high concentration of polyphenols, flavonoids (such as quercetin), and anthocyanins. Its seeds contain jambosine and ellagic acid, which are powerful inhibitors of α-amylase. Bitter melon, meanwhile, is defined by cucurbitacins, polypeptide-p (often called "plant insulin"), and momordicin. These compounds exhibit a multi-targeted approach, acting as insulin mimetics and antioxidants. [4]

In comparative trials, Jamun shows a dominant polyphenolic profile, while bitter melon is richer in polypeptides. Scientific data indicates that Jamun seed extracts can activate AMPK in muscle cells, increasing glucose uptake by 35%, a result comparable to metformin. Bitter melon extract (BME) has been shown to sensitize insulin-resistant cells via Akt phosphorylation and stimulate GLP-1 secretion. While animal models confirm that both can lower fasting glucose and repair pancreatic islets, head-to-head comparisons are rare. Literature suggests bitter melon may be superior for acute enzyme inhibition, while Jamun excels in long-term antioxidant protection. This study provides the first direct comparison using insulin-resistant cell lines to address this research void. [5-13]

1.4 Evidence from Previous Studies

Many studies support the antidiabetic activity of these plants.

In laboratory studies:

- Jamun extract increases glucose uptake and shows strong antioxidant activity
- It also inhibits enzymes like α-glucosidase, which reduces sugar absorption
- Bitter melon improves insulin sensitivity and activates glucose metabolism pathways

Animal studies show:

- Jamun reduces blood glucose and improves pancreatic function
- Bitter melon lowers glucose levels and increases insulin production

Some human studies also show benefits, although more research is needed.

However, direct comparison studies between Jamun and bitter melon are limited, which makes this research important.[3]

1.5 Mechanisms of Action

Both plants work through multiple mechanisms:

- **Enzyme inhibition:** Reduce carbohydrate digestion and glucose absorption
- **Improved insulin sensitivity:** Enhance glucose uptake in cells

- **Activation of AMPK pathway:** Helps regulate energy metabolism
- **Antioxidant action:** Reduces oxidative stress
- **β-cell protection:** Protects insulin-producing cells

Additionally, bitter melon may improve incretin hormones like GLP-1, which is not seen in Jamun.

1.6 Rationale of the Study

Although herbal medicines are widely used, there are still gaps in scientific understanding:

- Lack of direct comparison studies
- Limited mechanistic data
- Variation in extraction and testing methods

This study aims to fill these gaps by comparing Jamun and bitter melon using standardized in vitro methods.

Objectives of the Study

- To prepare and analyze extracts of Jamun and bitter melon
- To study enzyme inhibition activity
- To evaluate glucose uptake in cells
- To assess antioxidant and anti-inflammatory effects
- To check safety using cytotoxicity studies

Conclusion

This study aims to provide clear scientific evidence on the antidiabetic potential of Jamun and bitter melon. By comparing both plants, it helps identify which is more effective and how they work. This can support the development of safer and affordable herbal treatments for diabetes, especially in resource-limited settings.

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