

Review of the Efficacy of Ayurvedic Formulations in Diabetes Management

Bhushan Bhagvan Thakare^{1*}, K. P. Patil², Neha Patil², Mrunal D. Pendarker², S. P. Pawar³

Abstract

Diabetes mellitus is one of the most prevalent metabolic disorders globally, characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. It leads to serious complications affecting the cardiovascular, renal, and nervous systems, imposing a significant health and economic burden. In Ayurveda, diabetes is described as Madhumeha, a subtype of Prameha, primarily caused by the vitiation of Kapha dosha, Meda dhatu (fat metabolism), and Agnimandya (impaired digestion). The disease develops due to improper dietary habits, a sedentary lifestyle, and disturbed metabolic fire, leading to Srotorodha (microchannel obstruction) and systemic imbalance. Ayurvedic management emphasizes restoring metabolic harmony through Ahara (diet), Vihara (lifestyle modification), and Aushadhi (herbal therapy). Several herbs, such as Trigonella foenum-graecum (Fenugreek), Gymnema sylvestre (Gurmar), Phyllanthus emblica (Amla), Curcuma longa (Turmeric), Syzygium cumini (Jamun), and Momordica charantia (Bitter Melon), possess significant hypoglycemic, antioxidant, and lipid-regulating properties. These herbs act through multiple mechanisms, including insulin secretion enhancement, beta-cell regeneration, and oxidative stress reduction. Furthermore, polyherbal formulations, such as Diabecon, Hyponidd, and BGR-34, exhibit synergistic efficacy in glycemic control and metabolic correction. This review integrates classical Ayurvedic knowledge with modern pharmacological and clinical findings, highlighting the efficacy, mechanisms, and therapeutic potential of Ayurvedic herbs and formulations in the holistic management of diabetes mellitus (Madhumeha).

Keywords: Ayurveda, Madhumeha, diabetes mellitus, antidiabetic herbs, polyherbal formulations, insulin sensitivity, β -cell regeneration, oxidative stress, Rasayana, glucose metabolism

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to impaired insulin secretion or action [1, 2]. It affects carbohydrates, fat, and protein metabolism and leads to severe complications such as neuropathy, nephropathy, and cardiovascular diseases [3]. According to the International Diabetes Federation, over 537 million adults are living with diabetes globally, a number projected to rise to 700 million by 2045 [4]. Despite various oral hypoglycemic agents and insulin therapies, long-term management remains challenging due to adverse effects, and limited accessibility [5, 6].

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Ayurveda, the ancient Indian system of medicine, describes diabetes under the category of Prameha, with its chronic form known as Madhumeha [7, 8]. It attributes the disorder to Kapha-Meda dushti (fat metabolism disturbance), Agnimandya (impaired digestion), and Srotorodha (microchannel

obstruction) [9, 10]. These concepts parallel modern understandings of insulin resistance, β -cell dysfunction, and oxidative stress [11, 12].

Ayurveda proposes a holistic management strategy involving *Ahara* (diet), *Vihara* (lifestyle regulation), and *Aushadhi* (herbal therapy) [13, 14]. Numerous herbs – such as *Trigonella foenum-graecum*, *Gymnema sylvestre*, *Phyllanthus emblica*, and *Curcuma longa* – have shown hypoglycemic, antioxidant, and insulin-sensitizing activities [15, 16]. Polyherbal formulations, like Diabecon and BGR-34, further enhance efficacy through synergistic mechanisms [17, 18]. This review integrates Ayurvedic and modern insights to evaluate the efficacy and scientific basis of Ayurvedic formulations in diabetes management.

OVERVIEW OF DIABETES MELLITUS (MADHUMEHA)

Diabetes mellitus (DM) is a complex metabolic disorder characterized by chronic hyperglycemia resulting from impaired insulin secretion, insulin action, or both [19, 20]. It is associated with disturbances in carbohydrate, fat, and protein metabolism, leading to severe complications such as retinopathy, nephropathy, neuropathy, and cardiovascular diseases [21, 22]. Modern medicine classifies diabetes into Type 1, Type 2, and secondary forms caused by pancreatic or hormonal dysfunctions. Among these, Type 2 diabetes mellitus (T2DM) accounts for nearly 90–95% of cases.

Ayurveda, the ancient Indian medical system, identifies diabetes under the broader group of *Prameha*, comprising 20 urinary disorders classified based on the dominance of *Vata*, *Pitta*, or *Kapha doshas* [23, 24]. *Madhumeha*, a subtype of *Vataja Prameha*, is considered equivalent to chronic diabetes mellitus. The term *Madhumeha* is derived from “Madhu” (honey) and “Meha” (urination), symbolizing the passage of sweet urine due to elevated blood sugar [25, 26]. The disease originates from *Agnimandya* (impaired metabolism) and *Srotorodha* (microchannel obstruction), leading to deranged tissue metabolism (*Dhatvagnimandya*) and accumulation of *Ama* (toxic metabolites) [27, 28]. These pathological changes primarily affect *Meda dhatu* (adipose tissue) and *Mutravaha srotas* (urinary channels), causing excessive urination, thirst, and fatigue – hallmark features that parallel modern descriptions of polyuria, polydipsia, and weakness in diabetes [29, 30].

The *Nidana* (causative factors) described in Ayurvedic texts include excessive consumption of sweet, heavy, and oily foods; daytime sleep; lack of exercise; and psychological stress [22, 31]. These habits lead to *Kapha* and *Meda* accumulation, resulting in insulin resistance-like conditions. Over time, depletion of body tissues (*Dhatu kshaya*) and *Vata* aggravation correspond to β -cell exhaustion like the late stages of Type 2 DM [16, 24, 32].

Thus, both Ayurvedic and modern perspectives converge on the idea that *Madhumeha* is a lifestyle-induced metabolic disorder involving impaired glucose utilization and lipid metabolism [33]. Ayurveda’s emphasis on diet, physical activity, and herbal therapy highlights preventive and restorative measures that align closely with current global strategies for diabetes management.

AYURVEDIC PATHOPHYSIOLOGY OF MADHUMEHA

In Ayurveda, *Madhumeha* is described as a subtype of *Vataja Prameha*, one of the 20 varieties of *Prameha* mentioned in classical texts such as *Charaka Samhita* and *Sushruta Samhita* [9, 10]. The disease develops as a result of *Agnimandya* (weak digestive and metabolic fire), which leads to the formation of *Ama* (metabolic toxins) and imbalance in the three *Doshas* – *Vata*, *Pitta*, and *Kapha* [34, 35]. Among these, *Kapha* and *Meda dhatu* (adipose tissue) play the most critical roles in the early stages of *Madhumeha*, whereas *Vata* becomes predominant in the chronic stage, causing progressive tissue depletion and debility [36].

The disease process begins with improper diet and lifestyle habits such as overeating, excessive consumption of sweet and oily foods, daytime sleeping, and lack of exercise. These habits aggravate *Kapha dosha* and lead to the accumulation of *Meda* and *Mamsa dhatu*, which obstruct the *Srotas*

(microchannels) responsible for nutrient and fluid transportation [16, 17]. The blockage (*Srotorodha*) impairs the flow of vital substances and disrupts *Agni* (metabolic fire), resulting in incomplete digestion and production of *Ama* [37]. This *Ama* circulates throughout the body, further aggravating *Kapha* and *Meda*, leading to a metabolic imbalance like insulin resistance in modern pathophysiology [19, 20].

As the condition progresses, *Vata dosha* becomes aggravated due to tissue depletion (*Dhatukshaya*) and the body's inability to metabolize glucose properly. The dominance of *Vata* results in dryness, emaciation, and excessive urination – features that correspond to the catabolic phase of diabetes mellitus [21, 22]. The *Mutravaha srotas* (urinary channels) and *Medovaha srotas* (fat metabolism channels) are primarily affected, resulting in excessive production and excretion of urine with a sweet odor and taste (*Madhura mutrata*) [23, 24].

From a modern biomedical perspective, this Ayurvedic description closely parallels the progression from insulin resistance to β -cell dysfunction. *Agnimandya* represents metabolic inefficiency, *Srotorodha* symbolizes cellular receptor blockade, and *Dhatu-kshaya* signifies β -cell exhaustion and tissue catabolism [25].

Therefore, the Ayurvedic pathophysiology (Figure 1) of *Madhumeha* provides a holistic and dynamic understanding of diabetes, emphasizing the interplay of diet, lifestyle, and metabolism. It underscores the importance of restoring *Agni*, clearing *Ama*, and balancing *Doshas* through *Ahara* (diet), *Vihara* (lifestyle), and *Aushadhi* (herbal formulations) to achieve long-term disease reversal and systemic rejuvenation [26, 27].

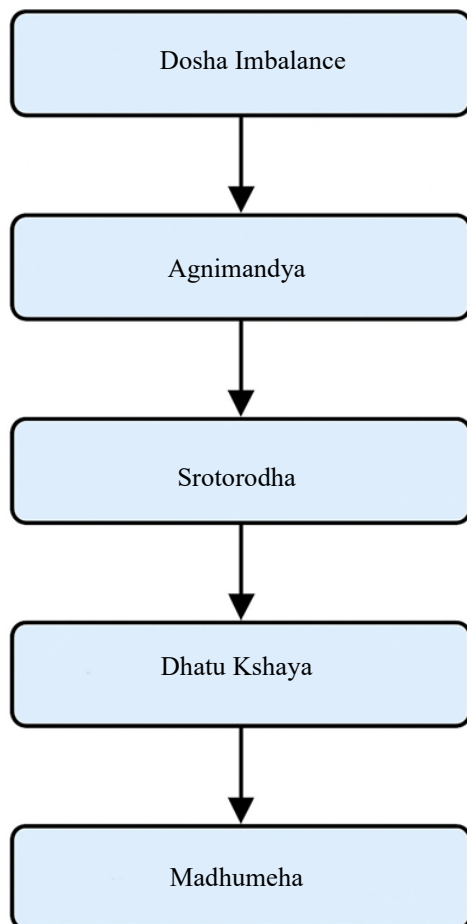


Figure 1. Ayurvedic pathogenesis of *Madhumeha* showing *Dosha* imbalance and *Srotorodha*.

AYURVEDIC HERBS AND FORMULATIONS IN DIABETES MANAGEMENT

Ayurvedic medicine offers a comprehensive and multi-target approach for the management of *Madhumeha* (Diabetes Mellitus) through a variety of single herbs (*Ekasudha Aushadhi*) and multi-herbal combinations (Polyherbal Formulations) [9, 10]. Unlike conventional drugs that target specific biochemical pathways, Ayurvedic herbs act synergistically on multiple physiological processes such as improving digestion, enhancing insulin sensitivity, reducing oxidative stress, and restoring tissue metabolism [14, 16].

Among the most studied herbs, *Trigonella foenum-graecum* (Fenugreek) seeds contain galactomannan fiber and 4-hydroxyisoleucine, which stimulate insulin secretion and delay glucose absorption in the intestine [30]. *Gymnema sylvestre* (Gurmar), also known as the “sugar destroyer,” contains gymnemic acids that suppress sweet taste sensation and inhibit intestinal glucose uptake while promoting β -cell regeneration [31]. *Phyllanthus emblica* (Amla) is rich in vitamin C and polyphenols that improve glucose metabolism, prevent lipid peroxidation, and enhance insulin sensitivity [15, 23]. Similarly, *Curcuma longa* (Turmeric) exhibits potent antioxidant and anti-inflammatory properties through its active constituent curcumin, which activates AMP-activated protein kinase (AMPK) and enhances glucose uptake [33].

Other herbs, such as *Syzygium cumini* (Jamun) and *Momordica charantia* (Bitter Melon), possess natural α -glucosidase inhibitory and insulin-mimetic properties, leading to reduced postprandial glucose levels [36]. *Aegle marmelos* (Bael) and *Azadirachta indica* (Neem) support hepatic glucose regulation and lipid metabolism, while *Pterocarpus marsupium* (Vijaysar) aids in β -cell regeneration and serum lipid control [27, 35]. Collectively, these herbs not only reduce hyperglycemia but also help prevent complications such as neuropathy, nephropathy, and oxidative tissue injury.

Polyherbal formulations further enhance therapeutic efficacy by combining herbs with complementary actions. Classical and modern formulations, like Diabecon, Hyponidd, BGR-34, and Nisha-Amalaki, have been clinically evaluated for their hypoglycemic and antioxidant effects [8, 25, 28]. These formulations act through multiple mechanisms, including improved glucose tolerance, insulin sensitization, lipid regulation, and free-radical scavenging activity.

Thus, Ayurvedic herbs and formulations offer a holistic, safe, and cost-effective alternative for diabetes management. Their multitargeted mechanisms not only control blood glucose but also correct the underlying metabolic disturbances, making them promising candidates for integrative therapeutic strategies in modern diabetes care (Table 1) [29, 32].

Table 1. Summary of key ayurvedic herbs and their mechanisms in diabetes management.

Herb	Primary mechanisms
<i>Trigonella foenum-graecum</i>	Enhances insulin secretion, delays glucose absorption.
<i>Gymnema sylvestre</i>	Regenerates-cells, inhibits intestinal glucose uptake.
<i>Phyllanthus emblica</i>	Antioxidant, improves insulin sensitivity.
<i>Curcuma longa</i>	Activates AMPK, reduces inflammation.
<i>Pterocarpus marsupium</i>	-cell regeneration, lipid lowering.

PHARMACOLOGICAL MECHANISMS AND SCIENTIFIC EVIDENCE

The pharmacological efficacy of Ayurvedic herbs and formulations in the management of *Madhumeha* (Diabetes Mellitus) is attributed to their multi-target mechanisms that collectively restore glucose homeostasis and metabolic balance [9, 10]. Unlike synthetic drugs that act on isolated molecular pathways, Ayurvedic herbs influence multiple biological systems, including pancreatic β -cells, hepatic metabolism, insulin receptors, and oxidative defense networks [14, 16].

A major mechanism involves stimulation of insulin secretion and β -cell regeneration. Herbs, such as *Gymnema sylvestre*, *Pterocarpus marsupium*, and *Momordica charantia*, enhance β -cell proliferation and restore pancreatic function, thereby improving endogenous insulin levels [31, 35, 36]. *Trigonella foenum-graecum* (Fenugreek) and *Aegle marmelos* (Bael) exhibit insulinotropic and glucose-lowering effects through delayed intestinal glucose absorption and enhanced glycogen synthesis [30, 35].

Another important mechanism is the improvement of insulin sensitivity. *Curcuma longa* (Turmeric) activates AMP-activated protein kinase (AMPK) and peroxisome proliferator-activated receptor-gamma (PPAR- γ), leading to enhanced glucose uptake in skeletal muscles and adipose tissues [33]. *Phyllanthus emblica* (Amla) and *Syzygium cumini* (Jamun) further regulate hepatic gluconeogenesis and promote glucose utilization [15, 27].

Herbs also exhibit strong antioxidants and anti-inflammatory activities, protecting tissues from oxidative stress-induced β -cell damage. Amla, Turmeric, and Neem contain flavonoids and phenolic compounds that neutralize reactive oxygen species, improving insulin receptor function [23, 32].

Scientific evidence from clinical studies supports these pharmacological actions. Polyherbal formulations, such as Diabecon, BGR-34, and Hyponidd, demonstrate significant reductions in fasting and postprandial blood glucose, HbA1c, and serum lipid levels, along with improved antioxidant enzyme activity [8, 25, 28]. These findings validate the traditional Ayurvedic approach, establishing its relevance as a complementary and integrative strategy in modern diabetes therapy [29].

CLINICAL STUDIES ADVANTAGES, LIMITATIONS AND FUTURE SCOPE

Clinical Studies

Numerous preclinical and clinical studies have validated the antidiabetic potential of Ayurvedic herbs and polyherbal formulations. *Trigonella foenum-graecum* (Fenugreek) seed powder has shown significant reductions in fasting blood glucose and HbA1c levels in Type 2 diabetes patients [30]. *Gymnema sylvestre* (Gurmar) extract enhances insulin secretion and regenerates pancreatic β -cells in both animal and human studies [31]. *Curcuma longa* (Turmeric) improves insulin sensitivity by activating AMPK pathways and reducing systemic inflammation [33]. Similarly, *Phyllanthus emblica* (Amla) and *Momordica charantia* (Bitter Melon) demonstrated hypoglycemic and lipid-regulating effects in diabetic models [15, 36].

Polyherbal formulations, such as Diabecon, Hyponidd, and BGR-34, have been clinically evaluated for their efficacy in managing Type 2 diabetes [8, 25, 28]. Diabecon reduced fasting plasma glucose by up to 20%.

Advantages

Ayurvedic management of *Madhumeha* offers multiple therapeutic advantages. Herbs act on several molecular targets simultaneously – stimulating insulin secretion, improving glucose uptake, reducing oxidative stress, and normalizing lipid metabolism [14, 16]. Unlike conventional drugs, Ayurvedic herbs exhibit minimal toxicity, are cost-effective, and are suitable for long-term use. Additionally, Ayurvedic formulations include *Rasayana* (rejuvenating) herbs that enhance vitality, improve immunity, and prevent secondary diabetic complications [27, 32]. The integration of dietary and lifestyle guidelines ensures comprehensive control over metabolic imbalance, offering preventive as well as curative benefits [18].

Limitations

Despite their promising efficacy, several limitations hinder the global acceptance of Ayurvedic formulations. Many studies lack randomized, double-blind, and large-scale clinical trials to establish reproducibility and standardized efficacy [23]. Variability in the quality and concentration of phytochemicals due to differences in plant origin, harvesting, and processing methods remains a concern. The absence of unified-dosing protocols and pharmacokinetic data limits clinical standardization [24, 25]. Additionally,

herb–drug interactions and long-term toxicity profiles are not well documented, warranting further research for regulatory approval and safety validation [20, 21].

Future Scope

Future research should focus on integrating Ayurvedic wisdom with modern biomedical science. Advanced analytical tools, such as metabolomics, molecular docking, and network pharmacology, can elucidate active phytoconstituents and their molecular targets [19, 22]. Standardized polyherbal formulations with defined phytochemical profiles and validated pharmacodynamics can enhance credibility and acceptance in global markets. Interdisciplinary collaborations between Ayurvedic scholars, pharmacologists, and clinical researchers are essential for evidence-based validation. Furthermore, promoting Good Manufacturing Practices (GMP) and establishing quality control frameworks will ensure product consistency and safety [29].

Ayurveda's holistic principles – addressing not only hyperglycemia but also oxidative stress, inflammation, and metabolic dysfunction – hold immense potential in redefining diabetes management. With sustained research and global collaboration, Ayurvedic formulations can evolve into scientifically recognized, sustainable, and integrative alternatives for diabetes care in the 21st century [9, 10, 37].

CONCLUSION

Ayurvedic herbs and formulations provide a holistic, multi-target approach to the management of *Madhumeha* (Diabetes Mellitus). Their synergistic actions – enhancing insulin secretion, improving glucose utilization, and reducing oxidative stress – address both symptoms and underlying metabolic imbalances. Clinical studies confirm significant hypoglycemic and antioxidant effects with minimal side effects. Despite the need for more standardized research, Ayurveda's integration with modern pharmacology offers a promising, sustainable, and cost-effective strategy for diabetes management. Continued interdisciplinary studies can establish Ayurveda as a scientifically validated complementary system for global diabetic care.

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