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Review Article

A Critical Review of *Momordica Charantia*, *Curcuma longa* & *Gymnema sylvestre* Polyherbal Systems For Diabetes Management

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ABSTRACT

Diabetes mellitus remains a major global health challenge, driving interest in polyherbal formulations as cost effective, multi target therapeutic options. *Gymnema sylvestre*, *Curcuma longa*, and *Momordica charantia* are widely used antidiabetic botanicals with complementary mechanisms of action. This narrative review critically examines the phytochemistry, pharmacological evidence, and formulation evaluation strategies relevant to developing polyherbal antidiabetic capsules containing these three plants. Key bioactive constituents, including gymnemic acids, curcuminoids, and charantin together with cucurbitanes, modulate glucose homeostasis by enhancing insulin secretion and sensitivity, inhibiting carbohydrate hydrolyzing enzymes, and acting through antioxidant and anti inflammatory pathways. Preclinical investigations consistently report hypoglycaemic and organ protective effects, while clinical studies support their adjunctive use in type 2 diabetes, although extract standardization and dosing regimens vary considerably. Encapsulation improves patient compliance, protects labile herbal actives, and allows flexible dosing, but demands careful control of moisture, powder flow, content uniformity, and marker based standardization. Recommended quality assessments comprise weight variation, disintegration, dissolution, microbial limits, heavy metal testing, and stability studies supported by HPLC/HPTLC fingerprinting of marker compounds. Polyherbal capsules combining *M. charantia*, *C. longa*, and *G. sylvestre* are both scientifically rational and pharmaceutically viable, provided that rigorous standardization, quality control, and safety evaluation are implemented. Robust clinical trials and bioavailability studies are required to confirm therapeutic benefit and optimize dosing schedules.

INTRODUCTION

Diabetes mellitus represents a substantial and escalating global health burden. According to the

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International Diabetes Federation, over half a billion adults were affected by diabetes in 2024, and current projections suggest a sharp increase in prevalence by 2050. A considerable share of these cases remains undiagnosed or poorly controlled, leading to microvascular and macrovascular complications and imposing heavy economic and societal costs on healthcare systems, especially in low- and middle-income countries. Although several classes of antidiabetic medications are available, issues such as secondary treatment failure, adverse effects, high costs, and the requirement for lifelong therapy have maintained interest in complementary approaches, including medicinal plants and polyherbal formulations[1,2,3].

Herbal medicines have been employed for centuries in traditional systems such as Ayurveda to manage “Prameha” (diabetes), and numerous botanicals are now being evaluated for their influence on glucose homeostasis, insulin sensitivity, and diabetes-related complications. Among these, *Momordica charantia* L. (bitter melon), *Curcuma longa* L. (turmeric), and *Gymnema sylvestre* (gurmar) are three of the most extensively researched antidiabetic plants. *M. charantia* contains several bioactive constituents, including charantin, cucurbitane-type triterpenoids, flavonoids, and polysaccharides, which have been reported to enhance peripheral glucose uptake through upregulation of GLUT4, suppress hepatic gluconeogenesis, and modulate intestinal glucose absorption by affecting SGLT1 and α -glucosidase activity. Both preclinical and clinical investigations indicate that *M. charantia* can reduce fasting blood glucose and HbA1c levels, while also exerting favorable effects on lipid parameters and oxidative stress markers[1,3,4].

Curcuma longa exerts its antidiabetic activity mainly through polyphenolic curcuminoids, particularly curcumin, which enhance insulin sensitivity, help preserve β -cell function, and mitigate chronic inflammation and oxidative stress by modulating AMPK, PI3K/Akt, and PPAR γ signaling pathways. Randomized controlled trials and mechanistic studies have shown that curcumin supplementation in individuals with type 2 diabetes or prediabetes can lower fasting glucose, HbA1c, and markers of insulin resistance. *Gymnema sylvestre*, which is rich in gymnemic acids and related saponins, has been reported to promote regeneration of pancreatic islet cells, stimulate insulin release, reduce intestinal glucose absorption, and inhibit α -glucosidase activity, thereby attenuating postprandial hyperglycemia. Collectively, these three botanicals act on complementary aspects of type 2 diabetes pathophysiology, namely insulin secretion and signaling, hepatic glucose production, intestinal carbohydrate digestion, and oxidative/inflammatory stress, offering a robust scientific basis for their inclusion in a single polyherbal formulation[1,5,6].

Polyherbal formulations are gaining attention as multi-target, cost-effective therapeutic strategies that may provide synergistic effects and a more favorable safety profile compared with single-herb preparations or synthetic monotherapies. Nevertheless, their conversion into reliable dosage forms depends on rigorous standardization, careful selection of the delivery system, and thorough quality assessment. Oral capsules are especially well suited for polyherbal powders and standardized extracts, as they enhance patient compliance, protect labile phytoconstituents, and allow flexible dosing; however, they also require strict control of moisture, powder flow, content uniformity, and stability. Accordingly, this review seeks to critically evaluate the phytochemical



profiles, pharmacological data, and formulation and evaluation approaches pertinent to developing polyherbal antidiabetic capsules containing *Momordica charantia*, *Curcuma longa*, and *Gymnema sylvestre*, with particular focus on standardization, quality control, and the translational gaps that must be resolved to support clinical adoption[1,2,7].

BOTANICAL PROFILES AND PHYTOCHEMISTRY

Momordica charantia L. (Cucurbitaceae)

Momordica charantia L. (bitter melon, karela) is a tropical vine whose fruits, leaves, and seeds are extensively employed in Ayurveda and other traditional medical systems for managing “Prameha” (diabetes) and related metabolic disorders. Its antidiabetic activity is ascribed to a complex array of secondary metabolites, notably cucurbitane-type triterpenoid glycosides and steroidal saponins[8,9].

Charantin, a mixture of sterol glucosides (β -sitosterol- β -D-glucoside and stigmasterol- β -D-glucoside), is the most widely cited marker compound for *M. charantia* and is frequently used to standardize extracts owing to its hypoglycaemic activity. Recent HPLC-based quantification across different genotypes has reported charantin contents of approximately 31–39 μ g/g fresh weight in high-accumulating lines, highlighting clear genotype-dependent variability and supporting the feasibility of marker-based standardization. Beyond charantin, *M. charantia* contains numerous momordicosides, karavilosides, and related cucurbitane triterpenoids, together with flavonoids (e.g., quercetin, rutin), phenolic acids (e.g., p-coumaric acid), and polysaccharides that contribute to antioxidant, anti-inflammatory, and glucose-lowering activities. Collectively, these

constituents influence key pathways involved in glucose homeostasis, including promotion of peripheral glucose uptake, inhibition of hepatic gluconeogenesis, and suppression of intestinal carbohydrate-digesting enzymes[8,9,10].

Curcuma longa L. (Zingiberaceae)

Curcuma longa L. (turmeric) is a perennial rhizomatous herb that is widely used both as a culinary spice and as a medicinal plant in Ayurveda and other traditional systems. The rhizome constitutes the principal medicinal part and is traditionally employed for inflammatory, metabolic, and hepatic conditions, including diabetes. Its phytochemical profile is dominated by non-volatile curcuminoids along with a volatile essential oil rich in turmerone-type sesquiterpenes[11]

Curcuminoids serve as the principal marker compounds for the identification and quality control of *C. longa*. The major curcuminoid, curcumin (diferuloylmethane), generally constitutes about 60–75% of the total curcuminoid fraction, with demethoxycurcumin and bisdemethoxycurcumin present in smaller proportions. International standards for turmeric used as a spice typically specify a minimum total curcuminoid content of approximately 2%, whereas dried rhizomes commonly contain 3–5% (w/w) total curcuminoids, varying with genotype, geographical origin, and processing conditions. Curcumin and related curcuminoids display pleiotropic biological activities, such as enhancing insulin sensitivity, preserving β -cell function, and mitigating oxidative stress and chronic inflammation through modulation of AMPK, PI3K/Akt, NF- κ B, and PPAR γ signaling pathways. These mechanisms help explain the reductions in fasting glucose, HbA1c, and markers of insulin resistance observed in preclinical and clinical studies of curcumin supplementation in



individuals with type 2 diabetes and prediabetes[12,13]

***Gymnema sylvestre* (Retz.) (Apocynaceae)**

Gymnema sylvestre (gurmar, “sugar destroyer”) is a woody climbing shrub indigenous to India and other tropical regions. Its leaves are traditionally employed in the management of diabetes, obesity, and dyslipidemia. The plant’s antidiabetic activity is mainly ascribed to a group of triterpenoid saponins known as gymnemic acids, together with related gymnemasaponins and other phytoconstituents.

Gymnemic acids consist of multiple analogues (commonly designated as gymnemic acids I–V and related derivatives) that share a gymnemagenin aglycone backbone with varying acyl substitutions. These compounds underlie the characteristic ability of *G. sylvestre* to suppress sweet taste perception and to inhibit intestinal glucose absorption. In addition to gymnemic acids, the leaves contain flavonoids, phenolic acids, anthraquinones, and other saponins that contribute to antioxidant and anti-inflammatory activities. From a pharmacological perspective, gymnemic acids have been reported to stimulate insulin secretion, promote regeneration of pancreatic islet cells, inhibit α -glucosidase activity, and reduce postprandial hyperglycemia, thereby complementing the mechanisms of *M. charantia* and *C. longa* within a polyherbal antidiabetic formulation. Recent studies have also isolated individual gymnemic acid analogues (e.g., gymnemic acid-III) using preparative HPLC, highlighting the feasibility of marker-based standardization for quality control purposes[13,14,15].

PHARMACOLOGICAL EVIDENCE:

***Momordica charantia*: preclinical and clinical evidence**

Preclinical investigations consistently show that *M. charantia* extracts and isolated constituents lower blood glucose via multiple mechanisms, including promotion of peripheral glucose uptake, inhibition of hepatic gluconeogenesis, modulation of insulin signaling, and suppression of carbohydrate-digesting enzymes. In streptozotocin-induced and high-fat diet-induced diabetic models, bitter melon preparations have been reported to improve fasting glucose levels, oral glucose tolerance, and lipid profiles, while also reducing markers of oxidative stress[9,10,16].

Clinical evidence, although heterogeneous with respect to plant part, extract type, and dosing regimen, supports a modest yet statistically significant glucose-lowering effect of *M. charantia*. A 2024 systematic review and meta-analysis of randomized controlled trials (RCTs) in type 2 diabetes mellitus (T2DM), assessed using the GRADE approach, reported that *M. charantia* supplementation significantly reduced fasting blood glucose (FBG), postprandial glucose (PPG), and HbA1c compared with placebo. Pooled data from eight RCTs ($n \approx 423$) yielded weighted mean differences of approximately -0.85 mmol/L for FBG and -0.38% for HbA1c, with more consistent effects observed in trials lasting ≥ 12 weeks. In another recent RCT involving 50 patients with T2DM, 12 weeks of treatment with standardized bitter melon extract capsules (1000 mg/day) significantly lowered oxidative stress (as reflected by reduced malondialdehyde levels) and increased superoxide dismutase activity, indicating antioxidant benefits in addition to glycemic improvements. Safety data across trials suggest good tolerability, with predominantly mild gastrointestinal complaints



and no serious adverse events attributed to *M. charantia*[17,18,19,20].

***Curcuma longa* (curcumin): preclinical and clinical evidence**

Preclinical studies indicate that curcumin and *C. longa* extracts enhance insulin sensitivity, protect β -cells, and mitigate inflammation and oxidative stress through modulation of AMPK, PI3K/Akt, NF- κ B, and PPAR γ signaling pathways. These mechanistic effects are reflected in clinically relevant improvements in both glycemic and inflammatory markers[13].

An umbrella review and updated meta-analyses published in 2023, evaluating *C. longa* supplementation in adults with T2DM, prediabetes, and metabolic syndrome, reported significant reductions in fasting blood glucose (mean difference ≈ -8.1 mg/dL) and HbA1c ($\approx -0.13\%$) compared with placebo or standard care. More recent randomized controlled trials further support these observations: a 2024 study in older adults with prediabetes demonstrated that daily administration of 80 mg curcumin for 12 weeks significantly lowered HbA1c relative to placebo, indicating a potential benefit in early stages of glucose dysregulation[22].

In patients with T2DM, 12 weeks of curcumin supplementation significantly reduced FBG, HbA1c, and C-reactive protein levels, indicating concurrent antihyperglycemic and anti-inflammatory effects. Another randomized controlled trial conducted in 2025 in T2DM patients with diabetic sensorimotor polyneuropathy reported that nano-curcumin (1500 mg/day for 14 weeks) ameliorated neuropathy severity and improved several cardiometabolic risk markers, although changes in HbA1c and FBG were not statistically significant across all subgroups. Taken together, clinical

evidence suggests that curcumin is most beneficial as an adjunctive therapy in early dysglycemia and in individuals with heightened inflammatory status, with a favorable safety and tolerability profile[23,24,25].

***Gymnema sylvestre*: preclinical and clinical evidence**

Preclinical investigations demonstrate that *G. sylvestre* extracts and gymnemic acids enhance insulin secretion, promote β -cell regeneration, inhibit intestinal glucose absorption, and suppress α -glucosidase activity. Network pharmacology and molecular docking studies have identified AKT1, PPARG, TNF, and IL-1 β as key molecular targets, with gymnemic acid I exhibiting strong binding affinity to AKT1 and stable interactions in molecular dynamics simulations, thereby supporting a multi-target antidiabetic mechanism of action[26, 27, 28].

Clinical evidence, although more limited compared with *M. charantia* and curcumin, is encouraging. A 2025 study combining in vitro and clinical work reported that 45 days of supplementation with *G. sylvestre* leaf extract (2 g/day) in human subjects significantly improved anthropometric and glycemic parameters, while cellular models showed enhanced glucose uptake and insulin secretion. Earlier trials using standardized *G. sylvestre* extracts (e.g., Om Santal Adivasi fraction, 1 g/day for 60 days) in patients with T2DM demonstrated reductions in fasting and postprandial blood glucose levels, along with increases in serum insulin and C-peptide, consistent with an insulintropic effect. A 2026 mechanistic review further summarized clinical findings indicating that standardized *G. sylvestre* extracts improve glycemic control and modulate lipid metabolism, with additional benefits on oxidative stress and inflammation that are relevant to diabetic complications. Safety profiles are



generally favorable, with mild gastrointestinal symptoms being the most frequently reported adverse effects[26,28,29].

Rationale for capsule dosage form

Oral delivery continues to be the most preferred route for antidiabetic therapy owing to its convenience, cost-effectiveness, and high patient compliance. In the case of polyherbal formulations, the selection of an appropriate dosage form must balance ease of administration, protection of labile phytoconstituents, dosing flexibility, and scalability of manufacturing. Among the available oral dosage forms, hard gelatin or HPMC capsules provide several advantages for combinations of herbal powders and standardized extracts, such as those derived from *Momordica charantia*, *Curcuma longa*, and *Gymnema sylvestre*[30,31,32].

Capsules allow direct filling of blended herbal powders or granulated extracts without subjecting the material to high compression forces, which is advantageous when handling hygroscopic, fibrous, or poorly compressible plant materials. This is especially relevant for *M. charantia* fruit powders, *C. longa* rhizome powders/extracts, and *G. sylvestre* leaf powders, which may display variable flow properties, moisture uptake, and compressibility depending on processing conditions. Encapsulation also offers superior protection against moisture, light, and oxygen compared with uncoated tablets or loose powders, thereby helping to preserve labile constituents such as curcuminoids, gymnemic acids, and cucurbitane triterpenoids[30,31,33,34].

From a patient-centric perspective, capsules are easy to swallow, effectively mask the bitter taste and strong odor associated with bitter melon and gurmar, and permit flexible dosing through adjustment of fill weight and capsule size.

Polyherbal capsules further enhance adherence by combining multiple botanicals into a single unit, thereby reducing pill burden compared with consuming individual herbal products. Regulatory and quality frameworks for herbal capsules are well established, with clear requirements for botanical identification, assay of marker compounds, microbial limits, heavy-metal testing, and stability evaluation, facilitating alignment with both AYUSH and modern pharmaceutical standards[30,35,36].

However, formulating polyherbal blends into capsules also poses several challenges, including control of moisture content, achievement of uniform fill weight, prevention of segregation among components with differing particle sizes and densities, and maintenance of chemical stability of key marker compounds throughout the product's shelf life. These issues can be addressed through appropriate drying and sieving steps, incorporation of glidants and lubricants (e.g., colloidal silicon dioxide, magnesium stearate), and selection of moisture-resistant capsule shells such as HPMC. Overall, capsules constitute a scientifically and pharmaceutically sound dosage form for a standardized polyherbal antidiabetic product combining *M. charantia*, *C. longa*, and *G. sylvestre*, provided that formulation design and quality control measures are rigorously applied[30,32,34].

Formulation design considerations for polyherbal capsules

Developing a robust polyherbal capsule containing *Momordica charantia*, *Curcuma longa*, and *Gymnema sylvestre* demands careful control of raw material quality, selection of extracts and powders, choice of excipients, and implementation of marker-based standardization. Herbal powders and extracts frequently exhibit hygroscopicity, poor flow properties, and batch-to-batch



variability in phytochemical composition, which can compromise capsule fill uniformity, stability, and therapeutic consistency. A rational formulation strategy therefore integrates standardized extracts (targeting key marker compounds) with processed powders and

appropriate excipients to achieve satisfactory flow characteristics, moisture control, and dosing precision, supported by validated analytical methods for charantin, curcuminoids, and gymnemic acids[33,37].

Table 1. Extract versus powder: implications for polyherbal antidiabetic capsules [35,37,38]

Aspect	Dried herbal powder	Standardized dry extract
Phytochemical control	Variable; depends on plant source and season	Better control via marker quantification (e.g., curcumin, gymnemic acids)
Dose precision	Less precise; requires larger fill weights	More precise; smaller fill for same marker dose.
Flow & compressibility	Often poor; fibrous, irregular particles	May be hygroscopic, gummy, cohesive.
Moisture sensitivity	Moderate; depends on drying and particle size	Often higher; amorphous extracts absorb moisture.
Manufacturing ease	Simple milling/sieving; may need granulation	May require co-processing with excipients.
Best use in PHF	As bulk filler, to improve flow and reduce cost	To fix marker content and biological activity.

Table 2. Common challenges in polyherbal capsule formulation and practical solutions[38,39,40]

Challenge	Why it occurs in herbal blends	Practical mitigation strategies
Hygroscopicity & stickiness	Amorphous extracts; sugars, saponins, polysaccharides	Vacuum/tray/freeze drying; co-processing with anhydrous lactose, MCC, mannitol.
Poor flow & segregation	Wide particle size distribution; different densities	Milling + sieving; use of glidants (colloidal SiO ₂ , talc); optimize lubricant (Mg stearate).
Moisture uptake & caking	High water activity in humid conditions	Moisture-resistant HPMC capsules; desiccant in primary packaging; controlled humidity storage.
Marker degradation over time	Heat, light, oxygen, moisture affect curcuminoids, etc.	Opaque/blister packaging; antioxidants; stability-indicating assays (HPLC/HPTLC).
Dose variability between batches	Natural variation in plant material	Use standardized extracts; set specification ranges for markers; fingerprinting.

Evaluation parameters:

Quality evaluation of polyherbal antidiabetic capsules containing *Momordica charantia*, *Curcuma longa*, and *Gymnema sylvestre* should adopt an integrated framework consistent with WHO guidelines for herbal medicines, the Indian Pharmacopoeia (IP), and the Ayurvedic Pharmacopoeia of India (API). This encompasses pre-formulation characterization of raw materials, in-process controls during blending and capsule filling, and comprehensive testing of the finished product for identity, purity, potency, and stability.

Critical tests include physicochemical parameters (weight variation, content uniformity, disintegration, dissolution), safety-related limits (microbial contamination, heavy metals, pesticide residues), and marker-based assays using validated HPLC/HPTLC methods for charantin, curcuminoids, and gymnemic acids. Stability studies conducted under accelerated and long-term conditions, designed in accordance with ICH Q1A principles, ensure that critical quality attributes and marker contents remain within specified limits throughout the product's shelf life[41,42,43].



Table 3: Quality control testing framework for polyherbal antidiabetic capsules[44-47]

Stage	Tests / Parameters	Purpose / Rationale
Raw material testing	Botanical identification (macroscopic, microscopic, DNA/barcoding where feasible)	Confirm identity of <i>M. charantia</i> , <i>C. longa</i> , <i>G. sylvestre</i> ; prevent substitution/adulteration
	Physicochemical: moisture, total ash, acid-insoluble ash, alcohol- and water-soluble extractive values	Assess purity, drying quality, and extractable matter as per API/IP
	Contaminants: heavy metals (Pb, As, Cd, Hg), pesticide residues, aflatoxins	Ensure safety; comply with WHO/IP limits
	Marker assay: charantin, curcuminoids, gymnemic acids (HPLC/HPTLC)	Establish baseline potency and batch consistency
In-process controls	Blend uniformity, particle size distribution, flow properties (angle of repose, Carr's index)	Ensure homogeneity and good flow for consistent capsule fill
	Moisture content of blend	Prevent caking, microbial growth, and marker degradation
	Fill weight check during capsule filling	Monitor content uniformity in real time
Finished product tests	Description (colour, odour, appearance), average fill weight, weight variation	Verify compliance with pharmacopeial limits for capsules
	Content uniformity (assay of markers in individual capsules or composite sample)	Confirm dose consistency across capsules
	Disintegration time (capsules)	Ensure timely release of herbal contents in GI tract
	Dissolution / drug release (if applicable; e.g., curcuminoids in biorelevant media)	Assess in vitro performance; support bioavailability claims
	Microbial limits: total aerobic count, yeast/mold, absence of specified pathogens (e.g., <i>E. coli</i> , <i>S. aureus</i>)	Ensure microbiological safety as per WHO/IP
	Heavy metals, pesticide residues (finished product, if not fully covered by raw material testing)	Final safety check on the dosage form
	Marker-based assay (charantin, curcuminoids, gymnemic acids) by validated HPLC/HPTLC	Confirm potency and standardization of final capsules
Stability studies	Accelerated (e.g., 40 °C/75% RH) and long-term (e.g., 30 °C/65% RH) as per ICH/WHO	Evaluate physical, chemical, and microbiological stability over shelf life
	Periodic testing: appearance, moisture, marker assay, microbial limits	Detect degradation, moisture uptake, or contamination during storage

Acceptance criteria

- Weight variation:** Capsules should comply with IP/USP limits for weight variation based on average fill weight (e.g., $\pm 7.5\%$ to $\pm 10\%$ for typical herbal fills)[43].
- Content uniformity:** Assay of each marker (charantin, total curcuminoids, gymnemic acids) within 90–110% of label claim for composite sample; tighter limits (e.g., 95–105%) if clinically justified[44].
- Disintegration time:** Capsules should disintegrate within 30 minutes in purified water at 37 ± 2 °C, unless modified release is intended[45].
- Microbial limits:** Total aerobic microbial count and total combined yeasts/molds count within WHO/IP specified limits for oral



herbal products; specified pathogens absent[45].

- e) **Heavy metals:** Lead, arsenic, cadmium, mercury below WHO/IP/AYUSH permissible limits (e.g., Pb $\leq$ 10 ppm, As $\leq$ 3 ppm, Cd $\leq$ 0.3 ppm, Hg $\leq$ 0.1 ppm, or as per national regulation)[48].
- f) **Pesticide residues:** Below maximum residue limits (MRLs) as per WHO and national guidelines[42].
- g) **Marker assay:** Each batch must meet predefined specifications for charantin, total curcuminoids, and gymnemic acids, supported by validated HPLC/HPTLC methods.
- h) **Stability:** No significant change in appearance, moisture, microbial limits, or marker content (e.g., $\leq$ 5–10% degradation) over the proposed shelf life under specified storage conditions[43].

Critical appraisal and research gaps

The current literature on *Momordica charantia*, *Curcuma longa*, and *Gymnema sylvestre* offers strong preclinical evidence and emerging clinical data supporting their antidiabetic potential via complementary mechanisms. Nevertheless, several critical gaps hinder the translation of this evidence into well-characterized polyherbal capsule products[49].

First, most clinical trials have examined single botanicals or non-standardized mixtures, with substantial heterogeneity in extract type, dosage, treatment duration, and outcome measures. Direct clinical evidence for this specific triple combination in a defined capsule formulation is currently unavailable, and no large-scale, long-duration randomized controlled trials have

evaluated efficacy, safety, and herb–drug interaction profiles in patients with type 2 diabetes receiving standard therapy[48,50].

Second, although marker-based standardization using charantin, curcuminoids, and gymnemic acids is analytically achievable, few studies have reported batch-to-batch phytochemical fingerprinting in conjunction with clinical outcomes, making it challenging to correlate specific phytoconstituent profiles with efficacy and safety[51,52].

Third, formulation research frequently concentrates on proof-of-concept preparation and basic physicochemical evaluation, with limited information on bioavailability, food effects, and pharmacokinetic interactions of the combined extract system.

Fourth, safety data are encouraging but remain incomplete, particularly concerning long-term use, special populations (pregnancy, elderly, and patients with renal or hepatic impairment), and interactions with commonly prescribed antidiabetic and cardiovascular medications[45,47].

Finally, there is a need for reproducible, clinically relevant biofilm and metabolic disease models, along with well-designed in vivo and human studies, to establish such polyherbal capsules as safety-evaluated antimicrobial or metabolic adjuvants rather than substitutes for standard therapy[48].

Bridging these gaps will demand integrated efforts that combine rigorous phytochemical standardization, robust formulation and stability studies, and adequately powered clinical trials with clearly defined endpoints and pharmacovigilance.



CONCLUSION

Polyherbal capsules combining *Momordica charantia*, *Curcuma longa*, and *Gymnema sylvestre* represent a scientifically rational and pharmaceutically viable strategy for the adjunctive management of type 2 diabetes. Preclinical and emerging clinical evidence supports complementary mechanisms of action directed at insulin secretion, insulin sensitivity, intestinal glucose absorption, and oxidative-inflammatory pathways. Nevertheless, variability in extract standardization, limited clinical data on this specific triple combination, and incomplete long-term safety and interaction profiles remain major constraints. Future research should prioritize well-designed randomized controlled trials using chemically characterized preparations, underpinned by rigorous quality control, stability evaluation, and pharmacovigilance. Such standardized polyherbal capsules could function as safety-evaluated metabolic adjuvants, rather than substitutes for established antidiabetic therapies.

REFERENCES

1. Teufel F, Orgutsova K, Genitsaridi I, Carrillo-Larco RM, Varghese JS, Marcus ME, Sacre JW, Sajjadi SF, Chiwanga F, Manne-Goehler J, Seiglie J. Global, regional, and national estimates of undiagnosed diabetes in adults: Findings from the 2025 IDF Diabetes Atlas. *Diabetes Care*. 2026 Mar 1;49(3):490-6.
2. Ayenew KD, Wondmkun YT, Endalifer BL, Seyfu A, Gebeyehu BT, Tsige AW, Sewale Bizu Y. The therapeutic role of medicinal plants in the management of diabetes. *Clinical Phytoscience*. 2026 Feb 16;12(1):2.
3. Li E, Maunder A, Liu J, Pandey C, Cave A, O'Fee A, Ee C. The efficacy and safety of herbal medicines for glycaemic control and insulin resistance in individuals with type 2 diabetes: an umbrella review. *BMC Complementary Medicine and Therapies*. 2025 Sep 30;25(1):341.
4. Mkhize SL, Phoswa WN, Ngubane S, Mokgalaboni K. Efficacy of *Momordica charantia* in glycaemic control and insulin resistance among patients with prediabetes and type 2 diabetes. A GRADE-adherent meta-analysis of randomised controlled trials. *Metabolism Open*. 2025 Oct 24;100407.
5. Bahari H, Jazinaki MS, Asadi Z, Golafrouz H. Curcumin/Turmeric Supplementation on Glycemic Control in Adults With Prediabetes and Type 2 Diabetes: A Systematic Review and Dose-Response Meta-Analysis. *Food Science & Nutrition*. 2026 Apr;14(4):e71748.
6. Kuzia N, Adamska O, Ksepka N, Wierzbicka A, Jóźwik A. Antidiabetic and anti-inflammatory potential of Zingiberaceae plants in dietary supplement interventions. *Molecules*. 2026 Jan 16;31(2):311.
7. Keith DS, Apte K, Kumawat VS, Chintamaneni A, Chintamaneni M, Sharma U, Sharma B, Shahwan M, Kaur G, Kaur D, Tuli HS. Phytochemical interventions of medicinal plants in the management of diabetes and obesity: A recent therapeutic overview. *Journal of Applied Pharmaceutical Science*. 2026 Jan;16(1):046-69.
8. Tharun B, Jat GS, Mangal M, Sunartiya V, Kumar S, Bhardwaj R, Singh N, Ranjan JK, Tomer A, Singh D, Behera TK. Molecular insights into charantin and β -carotene biosynthesis in bitter gourd (*Momordica charantia* L.): Gene expression dynamics and metabolite profiling. *Journal of Genetic Engineering and Biotechnology*. 2025 Dec 1;23(4):100626.
9. Tharun B, Jat GS, Singh D, Sunartiya V, Archana G, Kumar S, Bhardwaj R, Mangal M, Singh N, Ranjan JK, Tomer A. Comparative nutritional profiling among the genotypes of cultivated and wild species of bitter gourd based on bioactive compounds and mineral nutrients. *Discover Food*. 2026 Jun 14.
10. Ponphaiboon J, Krongrawa W, Limmatvapirat S, Limmatvapirat C. Efficient extraction of bioactive compounds from *Momordica charantia* L. fruits using ultrasound-assisted extraction and response surface methodology optimization.



- Ultrasonics Sonochemistry. 2025 Dec 11:107709.
11. Gafner S, Orhan N, Kahraman Ç, Blumenthal M. A scoping review of turmeric adulteration based on data from six continents. *Pharmaceutical Biology*. 2026 Dec 31;64(1):87-107.
12. Yun CI, Yang HJ, Lee J, Kim YJ. Validation, measurement uncertainty, and application of sesquiterpenoids and curcuminoids in turmeric (*Curcuma longa* L.) using HPLC-DAD and UHPLC-ESI-MS/MS: C.-I. Yun et al. *Food Science and Biotechnology*. 2025 Feb;34(3):611-20.
13. George M, Rajkumar A, Nair AK, Vincent B, VR C, Joseph L. A review on antidiabetic properties of *Momordica charantia*. *Journal of Pharma Insights and Research*. 2025 Jun 5;3(3):429-37.
14. Sivakumar A, Thanu AS, Vishnumukkala T, et al. Management of diabetes mellitus using medicinal plants: a review. *Bioinformation*. 2024;20(7):705-710.
15. Ouari S, Benaidane N, Brihi N, Arrar L, Trapali M. Molecular Anti-diabetic Potential of Medicinal Plants: A Review. *The Open Biochemistry Journal*. 2026 Jun 3;20(1).
16. Richter E, Geetha T, Burnett D, Broderick TL, Babu JR. The effects of *Momordica charantia* on type 2 diabetes mellitus and Alzheimer's disease. *International Journal of Molecular Sciences*. 2023 Feb 28;24(5):4643.
17. Grover JK, Yadav SP. Pharmacological actions and potential uses of *Momordica charantia*: a review. *Journal of ethnopharmacology*. 2004 Jul 1;93(1):123-32.
18. Basch E, Gabardi S, Ulbricht C. Bitter melon (*Momordica charantia*): a review of efficacy and safety. *American Journal of Health-System Pharmacy*. 2003 Feb 15;60(4):356-9.
19. Martin M. Nutritional and therapeutic benefits of bitter gourd (*Momordica charantia* L.). *Int. J. Agric. Nutr*. 2024;6:1-3.
20. F Fang E, B Ng T. Bitter gourd (*Momordica charantia*) is a cornucopia of health: a review of its credited antidiabetic, anti-HIV, and antitumor properties. *Current molecular medicine*. 2011 Jul 1;11(5):417-36.
21. Mokgalaboni K, Mashaba RG, Phoswa WN, Lebelo SL. Curcumin attenuates hyperglycemia and inflammation in type 2 diabetes mellitus: quantitative analysis of randomized controlled trial. *Nutrients*. 2024 Nov 30;16(23):4177.
22. Uchio R, Okuda-Hanafusa C, Sakaguchi H, Saji R, Muroyama K, Murosaki S, Yamamoto Y, Hirose Y. *Curcuma longa* extract reduces serum inflammatory markers and postprandial hyperglycemia in healthy but borderline participants with overweight and glycemia in the normal/prediabetes range: a randomized, double-blind, and placebo-controlled trial. *Frontiers in nutrition*. 2024 Jan 29;11:1324196.
23. AbdelAal AA, Abdelnabi AM. Study of subclinical atherosclerosis in patients with type 2 diabetes mellitus. *The Egyptian Journal of Hospital Medicine*. 2021 Apr 1;83(1):1203-7.
24. Alzamil H. Elevated serum TNF- α is related to obesity in type 2 diabetes mellitus and is associated with glycemic control and insulin resistance. *Journal of obesity*. 2020;2020(1):5076858.
25. Higgins JP, Sterne JA, Savovic J, Page MJ, Hróbjartsson A, Boutron I, Reeves B, Eldridge S. A revised tool for assessing risk of bias in randomized trials. *Cochrane database of systematic reviews*. 2016;10(Suppl 1):29-31.
26. Mkhize SL, Phoswa WN, Ngubane S, Mokgalaboni K. Efficacy of *Momordica charantia* in glycaemic control and insulin resistance among patients with prediabetes and type 2 diabetes. A GRADE-adherent meta-analysis of randomised controlled trials. *Metabolism Open*. 2025 Oct 24:100407.
27. Mayyas A, Al-Samydai A, Oraibi AI, Debbabi N, Hassan SS, Al-Hussainy HA, Salamatullah AM, Dauelbait M, Bourhia M, Almaary KS. Deciphering the Anti-Diabetic Potential of *Gymnema Sylvestre* Using Integrated Computer-Aided Drug Design and Network Pharmacology. *Journal of Cellular and Molecular Medicine*. 2025 Jan;29(1):e70349.



28. Lamichhane G, Godsey TJ, Liu J, Franks R, Zhang G, Emerson SR, Kim Y. Twelve-Week Curcumin supplementation improves glucose homeostasis and gut health in prediabetic older adults: A Pilot, Double-Blind, Placebo-Controlled trial. *Nutrients*. 2025 Jun 29;17(13):2164.
29. Ziyank-Demirtas S, Serin I. Gymnema sylvestre as a Multi-Target Antidiabetic Agent: Mechanistic Insights and Metabolic Regulation. *International Journal of Molecular Sciences*. 2026 Jun 22;27(12):5609.
30. Malarvizhi R, Abhishek P, Barathidasan, Potential wound healing properties of apolyherbal formulation in an experimental model on wistar rats. *Biomedicine*. 2020;39(1): 40-51
31. Shinde JS, Khurde SS, Suchita LS, Chanvan SS, Hulmajge SB. Need of polyherbal formulation and its standardization: A Review. *World J Pharm pharmacSci*. 2016;5(11):526-533.
32. Umme Seema N, SL Jagadeesh, Chandrashekar VM et al., Development and evaluation of the physical properties of polyherbal formulations for antiobesity, *The Pharma innovation journal*, 2022;11(11):1409-1412.
33. Kaundal R, Kumar D. Current demands for standardization of Indian medicinal plants: A critical review. *Medicine in Drug Discovery*. 2025 Sep 1;27:100211.
34. Vilegave, K., Vidyasagar, G. and Chandankar, P., 2013. Preformulation studies of pharmaceutical new drug molecule and products: An Overview. *The American Journal of Pharmacy*, 1(3), pp.1-20.
35. Wang H, Chen Y, Wang L, Liu Q, Yang S, Wang C. Advancing herbal medicine: enhancing product quality and safety through robust quality control practices. *Frontiers in pharmacology*. 2023 Sep 25;14:1265178.
36. Solecki RS. Standardized product as well as the quality of the consumer information on the herbal remedy. *hanidar IV. Science*. 1975;190:880.
37. Mudrić J, Arsenijević J, Maksimović Z, Ibrić S, Gopčević K, Đuriš J. Tablet and capsule formulations incorporating high doses of a dry optimized herbal extract: The case of *Satureja kitaibelii*. *Journal of Drug Delivery Science and Technology*. 2021 Dec 1;66:102776.
38. Shulammithi R, Sharanya M, Tejaswini R, Kiranmai M. Standardization and quality evaluation of herbal drugs. *IOSR Journal of Pharmacy and Biological Sciences*. 2016;11(5-1):89-100.
39. Proceedings of the Peradeniya University International Research Sessions (iPURSE) – 2025, University of Peradeniya, P.114
40. Tiwari NK, Alam M, Sarkar A. Development of herbal capsules containing standardized polyherbal extracts.
41. Bhandari R, Kuhad A, Paliwal JK, Kuhad A (2019) Development of a new, sensitive, and robust analytical and bio-analytical RP-HPLC method for in-vitro and in-vivo quantification of naringenin in polymeric nanocarriers. *J Anal Sci Technol* 10(1).
42. Kharat S, Namdeo A, Mehta P. Development and validation of HPTLC method for simultaneous estimation of curcumin and galangin in polyherbal capsule dosage form. *Journal of Taibah University for Science*. 2017 Sep 1;11(5):775-81.
43. Mallya P, Yarlagaadda DL, Lewis S. A novel stability-indicating RP-HPLC method for the simultaneous estimation and in vitro and in vivo evaluation: curcumin and naringin co-amorphous system. *Food Analytical Methods*. 2024 May;17(5):751-65.
44. Alam S, Sarker MM, Sultana TN, Chowdhury MN, Rashid MA, Chaity NI, Zhao C, Xiao J, Hafez EE, Khan SA, Mohamed IN. Antidiabetic phytochemicals from medicinal plants: prospective candidates for new drug discovery and development. *Frontiers in endocrinology*. 2022 Feb 24;13:800714.
45. Behl T, Gupta A, Albratty M, Najmi A, Meraya AM, Alhazmi HA, Anwer MK, Bhatia S, Bungau SG. Alkaloidal phytoconstituents for diabetes management: exploring the unrevealed potential. *Molecules*. 2022 Sep 9;27(18):5851.



46. Awasthi A, Kumar A, Kumar R, Vishwas S, Khursheed R, Kaur J, Corrie L, Kumar B, Gulati M, Kumar D, Kaushik M. RP-HPLC method development and validation for simultaneous estimation of mesalamine and curcumin in bulk form as well as nanostructured lipid carriers. *South African Journal of Botany*. 2022 Dec 1;151:529-37.
47. Ali T, Shah Z, Bashir R, Bader GN. The traditional medicine and phytoconstituents from natural products for liver disease: A review. *Journal of Drug Delivery & Therapeutics*. 2019 Mar 1;9(2):484-8.
48. Nakanekar A, Kohli K, Tatke P. Ayurvedic polyherbal combination (PDBT) for prediabetes: A randomized double blind placebo controlled study. *Journal of Ayurveda and integrative medicine*. 2019 Oct 1;10(4):284-9.
49. Zhang X, Zhao Y, Song Y, Miao M. Effects of *Momordica charantia* L. supplementation on glycemic control and lipid profile in type 2 diabetes mellitus patients: A systematic review and meta-analysis of randomized controlled trials. *Heliyon*. 2024 May 30;10(10).
50. Wang H, Chen Y, Wang L, Liu Q, Yang S, Wang C. Advancing herbal medicine: enhancing product quality and safety through robust quality control practices. *Frontiers in pharmacology*. 2023 Sep 25;14:1265178.
51. Noviana E, Indrayanto G, Rohman A. Advances in fingerprint analysis for standardization and quality control of herbal medicines. *Frontiers in Pharmacology*. 2022 Jun 2;13:853023.
52. Ziyank-Demirtas S, Serin I. *Gymnema sylvestre* as a Multi-Target Antidiabetic Agent: Mechanistic Insights and Metabolic Regulation. *International Journal of Molecular Sciences*. 2026 Jun 22;27(12):5609.

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