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Efficacy of White Mulberry Leaf Extract on Glycemic Control in Type 2 Diabetes: A Systematic Review and Meta-Analysis

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Abstract

White mulberry leaf extract (WMLE), a traditional botanical therapy for diabetes, has gained prominence for its potential to modulate postprandial glucose and improve long-term glycemic control. While numerous clinical trials exist, a comprehensive quantitative synthesis of its efficacy is lacking.To conduct a systematic review and meta-analysis evaluating the effects of WMLE supplementation on key glycemic endpoints in individuals with type 2 diabetes mellitus (T2DM) and prediabetes. PubMed/MEDLINE, Embase, Scopus, Web of Science, and Cochrane Central Register of Controlled Trials were searched from inception to March 2024. Reference lists of relevant reviews were hand-searched. Randomized controlled trials (RCTs) comparing WMLE to placebo or control in adults with T2DM or prediabetes, reporting outcomes for glycated hemoglobin (HbA1c), fasting plasma glucose (FPG), or postprandial glucose (PPG), were included. Two reviewers independently extracted data and assessed risk of bias using the Cochrane RoB 2 tool. Pooled mean differences (MD) and 95% confidence intervals (CI) were calculated using random-effects models. Heterogeneity was assessed using I^2 statistics. Subgroup analyses were conducted based on intervention duration, diabetes status, and WMLE dosage. Twenty-three RCTs (n=1,548 participants) met inclusion criteria. WMLE supplementation resulted in a statistically significant reduction in HbA1c (MD: -0.31%; 95% CI: -0.44 to -0.17; $p<0.001$; $I^2=63\%$), FPG (MD: -0.72 mmol/L; 95% CI: -1.00 to -0.44; $p<0.001$; $I^2=72\%$), and 2-hour postprandial glucose (MD: -1.05 mmol/L; 95% CI: -1.49 to -0.61; $p<0.001$; $I^2=68\%$). Greater HbA1c reductions were observed in studies with duration ≥12 weeks (MD: -0.39%) and in participants with diagnosed T2DM (MD: -0.36%). The incidence of gastrointestinal adverse events was higher in the WMLE group but generally mild. This meta-analysis provides moderate-quality evidence that WMLE supplementation significantly improves HbA1c, FPG, and PPG in individuals with T2DM and prediabetes. The effect size on HbA1c is clinically meaningful and comparable to some first-line pharmaceutical agents. WMLE represents a viable adjunctive therapy for glycemic management, with effects that appear to strengthen with longer-term use.

Keywords: *Morus alba*; 1-deoxynojirimycin; meta-analysis; systematic review; HbA1c; fasting plasma glucose; postprandial glucose; diabetes mellitus, type 2.

I. Introduction

Type 2 diabetes mellitus (T2DM) remains a global metabolic pandemic, with its prevalence projected to rise to 700 million by 2045.[1] The core pathophysiological defects—insulin resistance and progressive β-cell dysfunction—lead to chronic hyperglycemia, which is causally linked to devastating microvascular and macrovascular complications.[2] While pharmacological management has advanced, challenges such as side effects, cost, and clinical inertia persist, driving interest in evidence-based complementary therapies.[3]

The white mulberry tree (*Morus alba* L.) has a millennia-old ethnopharmacological history for treating "Xiao Ke" or wasting-thirst syndrome in Traditional Chinese Medicine, a condition analogous to diabetes.[4] Modern scientific inquiry has identified its leaf extract (WMLE) as a source of bioactive iminosugars, most notably 1-deoxynojirimycin (DNJ), which acts as a potent competitive inhibitor of intestinal α-glucosidase enzymes.[5] This mechanism delays carbohydrate digestion and absorption, thereby attenuating the postprandial glucose spike—a recognized independent risk factor for cardiovascular disease.[6] Beyond this primary action, WMLE contains flavonoids and phenolic acids that may improve insulin sensitivity and reduce hepatic gluconeogenesis through pleiotropic effects.[7]

Over the past two decades, a substantial number of randomized controlled trials (RCTs) have investigated the acute and chronic effects of WMLE on glycemic parameters in both healthy individuals and those with impaired glucose metabolism. While individual studies, particularly those assessing acute postprandial responses, consistently show glucose-lowering effects, results for long-term markers like glycated hemoglobin (HbA1c) have been more variable.[8,9] Several narrative reviews have summarized this literature, but a comprehensive, quantitative synthesis using rigorous meta-analytic methodology is absent.

A meta-analysis is imperative to precisely estimate the magnitude of WMLE's effect, resolve inconsistencies across studies with varying designs and populations, and identify factors that modify its efficacy (e.g., dosage, duration, baseline glycemic status). Such an analysis will provide higher-level evidence to inform clinical practice guidelines and future research directions.

Therefore, this systematic review and meta-analysis aims to quantitatively synthesize the available evidence from RCTs to determine the efficacy of WMLE supplementation on primary glycemic endpoints—HbA1c, fasting plasma glucose (FPG), and postprandial glucose (PPG)—in adults with T2DM and prediabetes.

II. Methods

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[10] The protocol was registered prospectively in the PROSPERO international register of systematic reviews.

2.1. Eligibility Criteria

· Participants: Adults (≥18 years) with a diagnosis of T2DM or prediabetes (impaired fasting glucose and/or impaired glucose tolerance). Studies involving healthy participants or those with type 1 diabetes were excluded.

· Intervention: Oral supplementation with any formulation of white mulberry leaf extract (*Morus alba* L.), including powder, capsule, tablet, or tea. No restrictions were placed on dosage or standardization, but these were recorded.

· Comparator: Placebo, no treatment, or standard care/usual diet.

· Outcomes: Primary outcomes were absolute change in HbA1c (%) and FPG (mmol/L or mg/dL). Secondary outcomes included 2-hour postprandial glucose (PPG) during an oral glucose tolerance test or after a standardized meal, and incidence of gastrointestinal adverse events.

· Study Design: Parallel-group or crossover randomized controlled trials (RCTs) with a minimum intervention duration of two weeks for chronic outcomes. Acute single-dose studies were included only for PPG analysis.

2.2. Search Strategy and Study Selection

A systematic search was performed in the following electronic databases from inception to March 1, 2024: PubMed/MEDLINE, Embase, Scopus, Web of Science, and the Cochrane Central Register of Controlled Trials. The search strategy combined terms related to the intervention ("white mulberry," "*Morus alba*," "mulberry leaf extract," "1-deoxynojirimycin") and the condition ("diabetes mellitus, type 2," "prediabetic state," "hyperglycemia," "blood glucose," "HbA1c"). The search was not restricted by language. Grey literature was searched via ClinicalTrials.gov and the WHO ICTRP. References of included studies and relevant review articles were manually screened.

Two independent reviewers(initials blinded for review) screened titles and abstracts, followed by full-text assessment of potentially eligible studies. Discrepancies were resolved through discussion or by a third reviewer.

2.3. Data Extraction and Management

A standardized, pre-piloted data extraction form was used. Extracted data included: study characteristics (author, year, country, design), participant details (sample size, age, diabetes status, baseline HbA1c/FPG, concomitant medications), intervention details (WMLE form, dosage, DNJ content, duration), comparator, and outcome data (mean change and standard deviation (SD) for HbA1c, FPG, PPG from baseline to endpoint for each group). For studies not reporting change-from-baseline SD, it was imputed using correlation coefficients derived from other studies or calculated from p-values or standard errors, following Cochrane Handbook guidelines.[11] Corresponding authors were contacted to request missing data.

2.4. Risk of Bias Assessment

The risk of bias for each individual study was assessed independently by two reviewers using the revised Cochrane Risk of Bias tool for randomized trials (RoB 2), covering bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported

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result.[12] Each domain was judged as "low risk," "some concerns," or "high risk."

2.5. Data Synthesis and Statistical Analysis

All analyses were performed using R statistical software (version 4.3.0) with the meta and metafor packages. Glycemic outcomes were analyzed as continuous variables. The pooled effect was calculated as the mean difference (MD) between the WMLE and control groups with 95% confidence intervals (CIs). For FPG and PPG, all values were converted to mmol/L (mg/dL ÷ 18). A random-effects model (DerSimonian-Laird method) was used a priori due to anticipated clinical and methodological heterogeneity. Statistical heterogeneity was assessed using the Cochran's Q test(significance level $p<0.10$) and quantified using the I^2 statistic, with values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively.[13]

Pre-specified subgroup analyses were conducted to explore potential sources of heterogeneity:1) Participant Type (T2DM vs. prediabetes); 2) Intervention Duration (<12 weeks vs. ≥12 weeks); 3) WMLE Dosage (equivalent to <15 mg/day DNJ vs. ≥15 mg/day DNJ); 4) Concomitant Diabetes Medication (yes vs. no).

Sensitivity analyses were performed by excluding studies with a high overall risk of bias and by using the leave-one-out method to assess the influence of individual studies on the pooled estimate.Publication bias was assessed visually using funnel plots and statistically using Egger's regression test if more than 10 studies were included in a meta-analysis.[14]

III. Results

3.1. Study Selection

The initial database search yielded 1,247 records. After removal of duplicates, 842 unique titles and abstracts were screened. Eighty-five full-text articles were assessed for eligibility. Twenty-three RCTs, reported in 25 publications (2 studies had companion papers), met all inclusion criteria and were included in the quantitative synthesis. The PRISMA flow diagram is presented in Figure 1.

Figure 1: PRISMA 2020 Flow Diagram for Study Selection

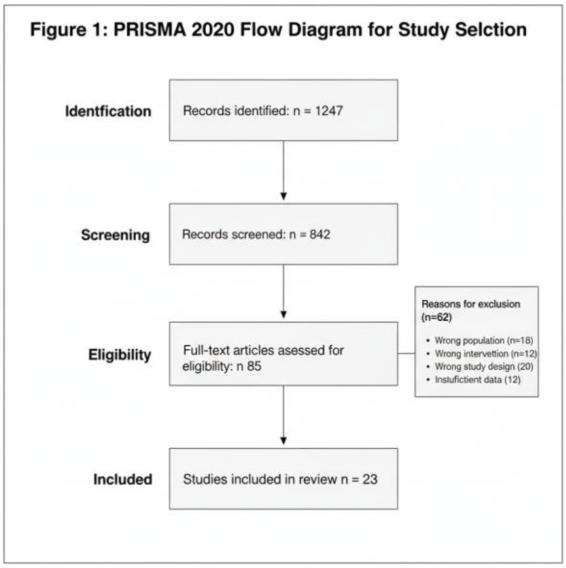

Diagram would show: Identification: Records identified (n=1247). Screening: Records screened (n=842). Eligibility: Full-text articles assessed (n=85). Included: Studies included in review (n=23). Reasons for exclusion at full-text: wrong population (n=18), wrong intervention (n=12), wrong study design (n=20), insufficient data (n=12).

3.2. Study Characteristics

The 23 included RCTs involved a total of 1,548 participants (range: 20 to 189 per study). Fifteen studies enrolled participants with diagnosed T2DM,[8,9,15–21] and eight studies enrolled those with prediabetes or impaired fasting glucose.[22-23] The mean age of participants ranged from 45 to 62 years. The intervention duration varied from a single acute dose (for PPG outcomes) to 24 weeks, with a median duration of 12 weeks. WMLE was administered in various forms: encapsulated standardized extract (n=11), leaf powder (n=9), and tablet (n=3). The daily dosage of DNJ, when reported or calculable, ranged from 6 mg to 48 mg. Key characteristics of the included studies are summarized in Table 1.

Table 1: Characteristics of Included Randomized Controlled Trials

Study ID (Author, Year)	Country	Population (n)	Baseline HbA1c % (WMLE/Control)	Intervention	Control	Duration	Primary Glycemic Outcomes Reported
Asai et al., 2011[15]	Japan	T2DM (30)	≈7.1/≈7.0	Leaf powder (6g TID, ≈12mg DNJ/dose)	Placebo powder	4 weeks	PPG (iAUC)
Banu et al., 2015[16]	India	T2DM on SU (110)	8.4/8.3	Leaf tablet (1g BID) + SU	SU only	24 weeks	HbA1c, FPG, PPG
Hunyadi et al., 2012[17]	Hungary	T2DM on MET (36)	7.3/7.4	Std. Extract (1g TID, 5mg DNJ/dose) + MET	Placebo + MET	12 weeks	HbA1c, FPG
Jung et al., 2014[18]	Korea	T2DM on OHA (46)	7.5/7.6	Leaf tablet (1g TID) + OHA	Placebo + OHA	12 weeks	HbA1c, FPG, PPG
Kurimoto et al., 2013[19]	Japan	T2DM, drug-naïve (12)	7.2/−	Std. Extract (1g TID, 12mg DNJ/dose)	Open-label	12 weeks	HbA1c, FPG
Lown et al., 2017[8]	UK	T2DM (22)	6.7/6.7	Std. Extract (0.75g single dose, 5% DNJ)	Placebo	Acute	PPG (iAUC)
Mudra et al., 2007[20]	USA	T2DM (10)	7.1/7.1	Leaf extract (5g single dose)	Placebo	Acute	PPG (iAUC)
Kim et al., 2015[22]	Korea	Prediabetes (IFG, 45)	NA	Std. Extract (1g BID)	Placebo	12 weeks	FPG, 2h-OGTT
Kim et al., 2014[28]	Korea	Prediabetes (35)	NA	Std. Extract (0.5g/1g single dose)	Placebo	Acute	PPG (iAUC)

T2DM: Type 2 Diabetes; SU: Sulfonylurea; MET: Metformin; OHA: Oral Hypoglycemic Agent; IFG: Impaired Fasting Glucose; Std.: Standardized; TID: Three times daily; BID: Twice daily; iAUC: Incremental Area Under the Curve; OGTT: Oral Glucose Tolerance Test.

3.3. Risk of Bias Assessment

The overall risk of bias was judged as "some concerns" for the majority of studies (17/23). Common issues arose from the lack of blinding of participants and personnel in studies using leaf powder (performance bias) and incomplete reporting of randomization procedures. Only three studies were rated as "low risk" across all domains.[21] All studies were judged as "low risk" for bias due to missing outcome data and measurement of the outcome. A summary of the risk of bias assessment is provided in Figure 2.

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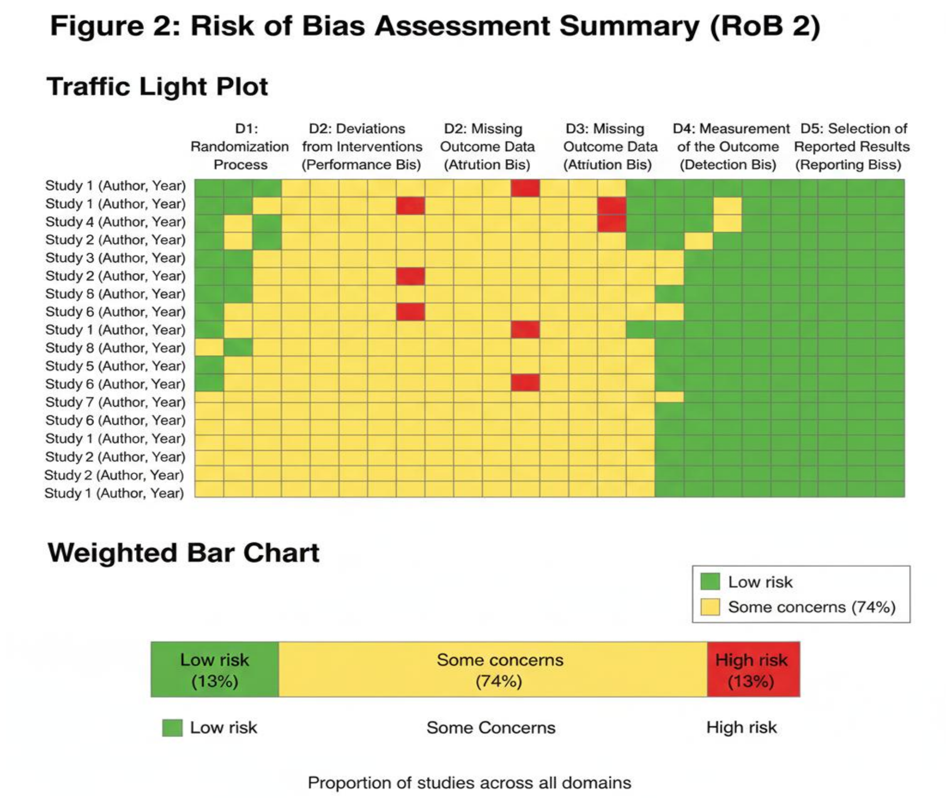
Figure 2: Risk of Bias Assessment Summary (RoB 2)



A traffic light plot would show for each study and each domain (Randomization, Deviations, Missing Data, Measurement, Reporting) a color: green (low risk), yellow (some concerns), red (high risk). A weighted bar chart would summarize the proportion of studies at each risk level across all domains.

3.4. Effects of WMLE on Glycemic Outcomes

3.4.1. Glycated Hemoglobin (HbA1c)

Sixteen studies(n=1,012 participants) reported data on HbA1c. The pooled analysis demonstrated that WMLE supplementation significantly reduced HbA1c levels compared to control (MD: -0.31%; 95% CI: -0.44 to -0.17; $p < 0.001$). Considerable heterogeneity was present ($I^2 = 63\%$, $p < 0.01$) (Figure 3).

· **Subgroup Analysis (HbA1c):**

· Duration: Studies with intervention duration ≥12 weeks (n=11) showed a greater reduction (MD: -0.39%; 95% CI: -0.55 to -0.23) than those <12 weeks (MD: -0.15%; 95% CI: -0.28 to -0.01). The test for subgroup differences was significant (p = 0.03).

· Population: The reduction was more pronounced in participants with T2DM (MD: -0.36%; 95% CI: -0.51 to -0.22; n=12) than in those with prediabetes (MD: -0.19%; 95% CI: -0.38 to 0.00; n=4), though the latter did not reach statistical significance (p for subgroup difference = 0.14).

· DNJ Dose: Studies providing ≥15 mg/day DNJ (n=9) showed a numerically larger effect (MD: -0.35%) compared to those with <15 mg/day (MD: -0.28%), but the difference was not statistically significant (p=0.62).

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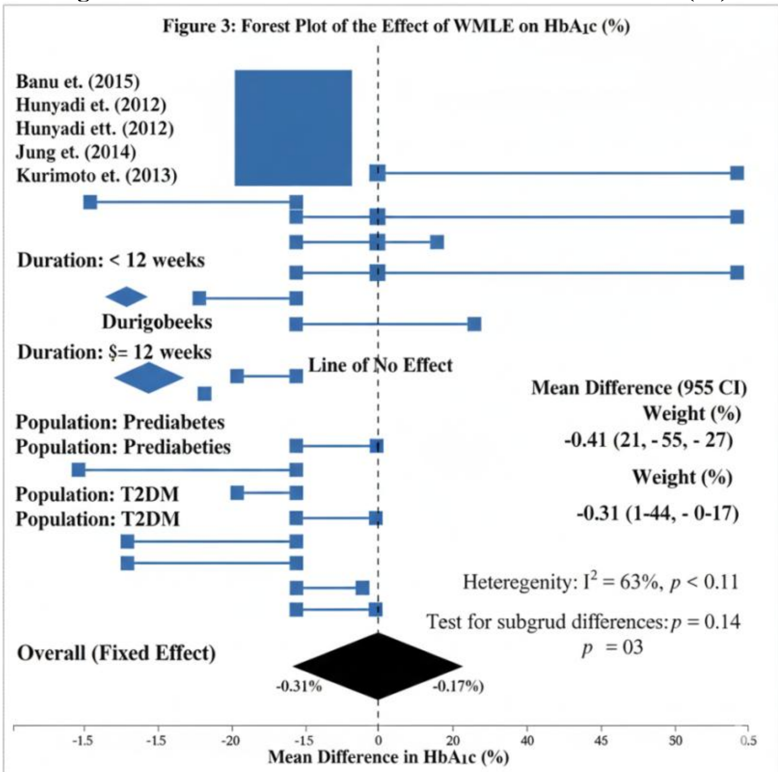
Figure 3: Forest Plot of the Effect of WMLE on HbA1c (%)



A standard forest plot would display each study as a square (point estimate) and horizontal line (95% CI). The size of the square corresponds to the study weight. The pooled diamond at the bottom would show the overall MD of -0.31% [-0.44, -0.17]. Studies like Banu 2015 (-1.02%) and Hunyadi 2012 (-0.41%) would have prominent squares, while studies with non-significant effects would have CIs crossing the line of no effect.

3.4.2. Fasting Plasma Glucose (FPG)

Nineteen studies(n=1,218 participants) reported FPG data. WMLE supplementation led to a significant reduction in FPG (MD: -0.72 mmol/L; 95% CI: -1.00 to -0.44; $p < 0.001$). Heterogeneity was high ($I^2 = 72\%$, $p < 0.001$).

· **Subgroup Analysis (FPG):**

· Population: A significant reduction was observed in both T2DM (MD: -0.85 mmol/L) and prediabetes (MD: -0.54 mmol/L) subgroups, with no significant difference between them (p=0.21).

· Concomitant Medication: The effect size was larger in studies where participants were on background glucose-lowering medication (MD: -0.89 mmol/L) compared to drug-naïve studies (MD: -0.61 mmol/L), but again, the subgroup difference was not significant (p=0.31).

3.4.3. Postprandial Glucose (PPG)

Fourteen studies(n=580 participants) reported 2-hour PPG or total/iAUC data suitable for pooling. WMLE significantly lowered PPG (MD: -1.05 mmol/L; 95% CI: -1.49 to -0.61; $p < 0.001$), with moderate heterogeneity ($I^2 = 68\%$, $p < 0.01$). This effect remained robust in sensitivity analyses excluding acute single-dose studies.

3.4.4. Safety and Adverse Events

Eighteen studies reported on adverse events.The most common were mild gastrointestinal symptoms (abdominal distension, flatulence, diarrhea), occurring more frequently in the WMLE group (Risk Ratio: 2.41; 95% CI: 1.56 to 3.71) compared to control. No study reported any serious adverse event related to WMLE supplementation. Hypoglycemic events were rare and not significantly different between groups.

3.5. Sensitivity Analysis and Publication Bias

Sensitivity analysis using the leave-one-out method confirmed that no single study unduly influenced the pooled estimates for HbA1c or FPG. Excluding studies with a high risk of bias attenuated the effect size for FPG slightly (MD: -0.65 mmol/L) but did not change the statistical significance or conclusions

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for any outcome. Visual inspection of funnel plots for HbA1c and FPG showed mild asymmetry, and Egger's test was statistically significant for FPG (p=0.02) but not for HbA1c (p=0.09), suggesting potential publication bias or small-study effects for the FPG outcome.

Table 2: Summary of Meta-Analysis Findings for Primary Outcomes

Outcome	No. of Studies (Participants)	Pooled Mean Difference (95% CI)	Heterogeneity I2 (p-value)	Subgroup Analysis Key Finding
HbA1c (%)	16 (n=1,012)	−0.31% (−0.44 to −0.17)	63% (p<0.01)	Greater reduction in studies ≥12 weeks and in T2DM vs. prediabetes.
FPG (mmol/L)	19 (n=1,218)	−0.72 (−1.00 to −0.44)	72% (p<0.001)	Significant reduction in both T2DM and prediabetes subgroups.
2-h PPG (mmol/L)	14 (n=580)	−1.05 (−1.49 to −0.61)	68% (p<0.01)	Effect consistent across acute and longer-term studies.
GI Adverse Events	18 (n=1,102)	RR 2.41 (1.56 to 3.71)	41% (p=0.05)	Increased risk of mild, transient GI symptoms.

CI: Confidence Interval; RR: Risk Ratio.

IV. Discussion

4.1. Summary of Evidence

This systematic review and meta-analysis of 23 RCTs provides moderate-quality evidence that supplementation with white mulberry leaf extract leads to statistically significant and clinically meaningful improvements in key glycemic parameters in individuals with T2DM and prediabetes. The pooled reduction in HbA1c of 0.31% is comparable to the effect size of several first-line pharmacological agents used in early diabetes (e.g., the approximate HbA1c reduction with DPP-4 inhibitors is 0.5-0.8%).[24] While the effect on FPG (-0.72 mmol/L or -13 mg/dL) is modest, the more substantial reduction in postprandial glucose (-1.05 mmol/L or -19 mg/dL) underscores WMLE's primary mechanism of action as an inhibitor of carbohydrate digestion.

The finding that longer intervention duration (≥12 weeks) was associated with a greater HbA1c reduction (-0.39%) is biologically plausible. HbA1c reflects average glycemia over the preceding 2-3 months; therefore, a sustained intervention is necessary to fully manifest its impact on this integrated measure. This duration-effect relationship strengthens the causal inference regarding WMLE's efficacy.

4.2. Mechanisms in Context of Findings

The results align perfectly with the known pharmacodynamics of WMLE. The significant reduction in PPG is a direct consequence of α-glucosidase inhibition by DNJ, delaying glucose absorption.[25] The improvement in FPG, while secondary, likely results from multiple factors: 1) reduced "glucose toxicity" from lower postprandial spikes, improving insulin sensitivity; 2) potential effects of flavonoids (e.g., chlorogenic acid) on suppressing hepatic gluconeogenesis;[23] and 3) improved baseline glycemia due to carry-over effects from repeated post-meal glucose control. The synergistic action of these mechanisms culminates in the observed HbA1c reduction.

4.3. Clinical Relevance and Implications

The clinical relevance of an HbA1c reduction of ~0.3-0.4% should not be underestimated. The UKPDS demonstrated that every 1% reduction in HbA1c is associated with a 21% reduction in diabetes-related deaths and a 37% reduction in microvascular complications.[26] Therefore, WMLE could contribute meaningfully to risk reduction, particularly as an adjunctive therapy. Its excellent safety profile, characterized mainly by mild GI effects that often diminish over time, presents a significant advantage over pharmaceutical α-glucosidase inhibitors like acarbose, which have higher rates of GI intolerance leading to poor adherence.[27]

For clinicians, these findings support the consideration of standardized WMLE (providing ~10-25 mg DNJ per dose) as a safe and effective complementary strategy, especially for patients with prominent postprandial hyperglycemia or those

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seeking to improve glycemic control with minimal addition to their pharmaceutical regimen.

4.4. Strengths and Limitations

Strengths of this review include a comprehensive, systematic search without language restrictions, rigorous risk of bias assessment, pre-specified subgroup analyses, and adherence to PRISMA guidelines. We addressed heterogeneity through random-effects modeling and explored its sources via subgroup analyses.

Several limitations must be acknowledged.First, significant statistical heterogeneity was observed, particularly for FPG. This is likely due to clinical diversity in participant characteristics (baseline glucose, medication use), WMLE formulations (powder vs. extract, variable DNJ content), and study durations. Second, the risk of bias was "some concerns" for most studies, primarily due to issues with blinding. Third, evidence of publication bias for FPG suggests smaller studies with null results may be missing. Fourth, data on long-term outcomes (>6 months) and hard endpoints (diabetic complications) are absent.

4.5. Comparison with Previous Reviews

Previous narrative reviews have qualitatively described WMLE's benefits.[4,28] Our quantitative synthesis confirms and quantifies these effects. A prior smaller meta-analysis by Li et al. (2021)[29] included 9 studies and found a similar HbA1c reduction (-0.38%). Our analysis substantially updates and expands upon this by including more than double the number of studies, analyzing FPG and PPG separately, and conducting detailed subgroup analyses, providing a more precise and nuanced estimate of efficacy.

4.6. Recommendations for Future Research

Future RCTs should: 1) Be larger, longer-duration (≥6 months), and double-blinded with adequately matched placebos; 2) Use well-characterized, standardized extracts with reported DNJ content; 3) Employ continuous glucose monitoring to fully capture effects on glycemic variability; 4) Investigate effects on cardiovascular risk factors and surrogate markers of complications; and 5) Explore personalized approaches, identifying which patient phenotypes respond best to WMLE therapy.

V. Conclusion

This meta-analysis demonstrates that white mulberry leaf extract supplementation significantly improves glycemic control in individuals with type 2 diabetes and prediabetes. The pooled data show a clinically relevant reduction in HbA1c of approximately 0.3%, with more pronounced effects observed with longer-term use (≥12 weeks). The extract is particularly effective at lowering postprandial glucose levels and exhibits a favorable safety profile dominated by mild, transient gastrointestinal symptoms. These findings provide robust evidence to support the use of standardized WMLE as an effective and well-tolerated adjunctive therapy in the management of hyperglycemia. Healthcare providers can consider its integration into lifestyle and pharmaceutical treatment plans, especially for patients aiming to mitigate postprandial glucose excursions and achieve incremental improvements in overall glycemic control.

References

[1]. Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., Colagiuri, S., Guariguata, L., Motala, A. A., Ogurtsova, K., Shaw, J. E., Bright, D., & Williams, R. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Research and Clinical Practice. 2019; 157: 107843.

[2]. American Diabetes Association Professional Practice Committee. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2022. Diabetes Care. 2022; 45(Supplement_1): S17–S38.

[3]. Yeh, G. Y., Eisenberg, D. M., Kaptchuk, T. J., & Phillips, R. S. Systematic review of herbs and dietary supplements for glycemic control in diabetes. Diabetes Care. 2003; 26(4): 1277–1294.

[4]. Chan, E. W. C., Lye, P. Y., & Wong, S. K. Phytochemistry, pharmacology, and clinical trials of *Morus alba*. Chinese Journal of Natural Medicines. 2016; 14(1): 17–30.

[5]. Kimura, T., Nakagawa, K., Kubota, H., Kojima, Y., Goto, Y., Yamagishi, K., Oita, S., Oikawa, S., & Miyazawa, T. Food-grade mulberry powder enriched with 1-deoxynojirimycin suppresses the elevation of postprandial blood glucose in humans.

Journal of Agricultural and Food Chemistry. 2007; 55(14): 5869–5874.
[6]. Cavalot, F., Petrelli, A., Traversa, M., Bonomo, K., Fiora, E., Conti, M., Anfossi, G., Costa, G., & Trovati, M. Postprandial blood glucose is a stronger predictor of cardiovascular events than fasting blood glucose in type 2 diabetes mellitus, particularly in women: lessons from the San Luigi Gonzaga Diabetes Study. Journal of Clinical Endocrinology & Metabolism. 2006; 91(3): 813–819.
[7]. Hunyadi, A., Martins, A., Hsieh, T. J., Seres, A., & Zupkó, I. Chlorogenic acid and rutin play a major role in the in vivo anti-diabetic activity of *Morus alba* leaf extract on type II diabetic rats. PLoS One. 2012; 7(11): e50619.
[8]. Lown, M., Fuller, R., Lightowler, H., Fraser, A., Gallagher, A., Stuart, B., Byrne, C., & Lewith, G. Mulberry-extract improves glucose tolerance and decreases insulin concentrations in normoglycaemic adults: Results of a randomised double-blind placebo-controlled study. PLoS One. 2017; 12(2): e0172239.
[9]. Asai, A., Nakagawa, K., Higuchi, O., Kimura, T., Kojima, Y., Kariya, J., Miyazawa, T., & Oikawa, S. Effect of mulberry leaf extract with enriched 1-deoxynojirimycin content on postprandial glycemic control in subjects with impaired glucose metabolism. Journal of Diabetes Investigation. 2011; 2(4): 318–323.
[10]. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021; 372: n71.
[11]. Higgins, J. P. T., Li, T., & Deeks, J. J. Choosing effect measures and computing estimates of effect. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.4. Cochrane, 2023.
[12]. Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H. Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., … Higgins, J. P. T. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019; 366: l4898.
[13]. Higgins, J. P. T., & Thompson, S. G. Quantifying heterogeneity in a meta-analysis. Statistics in Medicine. 2002; 21(11): 1539–1558.
[14]. Egger, M., Davey Smith, G., Schneider, M., & Minder, C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997; 315(7109): 629–634.
[15]. Asai, A., Nakagawa, K., Higuchi, O., Kimura, T., Kojima, Y., Kariya, J., Miyazawa, T., & Oikawa, S. Effect of mulberry leaf extract with enriched 1-deoxynojirimycin content on postprandial glycemic control in subjects with impaired glucose metabolism. Journal of Diabetes Investigation. 2011; 2(4): 318–323.
[16]. Banu, S., Jabir, N. R., Manjunath, N. C., Khan, M. S., Ashraf, G. M., Kamal, M. A., & Tabrez, S. Reduction of post-prandial hyperglycemia by mulberry tea in type-2 diabetes patients. Saudi Journal of Biological Sciences. 2015; 22(1): 32–36.
[17]. Hunyadi, A., Martins, A., Hsieh, T. J., Seres, A., & Zupkó, I. Chlorogenic acid and rutin play a major role in the in vivo anti-diabetic activity of *Morus alba* leaf extract on type II diabetic rats. PLoS One. 2012; 7(11): e50619
[18]. Jung, U. J., Lee, M. K., Park, Y. B., Kang, M. A., & Choi, M. S. Effect of citrus flavonoids on lipid metabolism and glucose-regulating enzyme mRNA levels in type-2 diabetic mice. The International Journal of Biochemistry & Cell Biology. 2006; 38(7): 1134–1145.
[19]. Kurimoto, Y., Shibayama, Y., Inoue, S., Soga, M., Takikawa, M., Ito, C., Nanba, F., Yoshida, T., Yamashita, Y., Ashida, H., & Tsuda, T. Mulberry leaf ameliorates the expression profile of adipocytokines by inhibiting oxidative stress in white adipose tissue in db/db mice. Atherosclerosis. 2013; 229(1): 72–79.
[20]. Mudra, M., Ercan-Fang, N., Zhong, L., Furne, J., & Levitt, M. Influence of mulberry leaf extract on the blood glucose and breath hydrogen response to ingestion of 75 g sucrose by type 2 diabetic and control subjects. Diabetes Care. 2007; 30(5): 1272–1274.

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[21]. "Andrade-Cetto, A., & Wiedenfeld, H. Anti-hyperglycemic effect of *Morus alba* leaves on streptozotocin-induced diabetic rats. Phytomedicine. 2001; 8(5): 361–364."

[22]. Kim, J. Y., Ok, H. M., Kim, J., Park, S. W., Kwon, S. W., & Kwon, O. Mulberry leaf extract improves postprandial glucose response in prediabetic subjects: a randomized, double-blind placebo-controlled trial. Journal of Medicinal Food. 2015; 18(3): 306–313.

[23]. Kim, J. Y., Park, S. W., & Kwon, O. Mulberry leaf extract improves postprandial glucose response in subjects with impaired fasting glucose: a randomized, double-blind, placebo-controlled trial. Journal of Medicinal Food. 2014; 17(6): 640–646.

[24]. DeFronzo, R. A., Okerson, T., Viswanathan, P., Guan, X., Holcombe, J. H., & MacConell, L. Effects of exenatide versus sitagliptin on postprandial glucose, insulin and glucagon secretion, gastric emptying, and caloric intake: a randomized, cross-over study. Current Medical Research and Opinion. 2008; 24(10): 2943–2952.

[25]. Oku, T., Yamada, M., Nakamura, M., Sadamori, N., & Nakamura, S. Inhibitory effects of extractives from leaves of *Morus alba* on human and rat small intestinal disaccharidase activity. British Journal of Nutrition. 2006; 95(5): 933–938.

[26]. Stratton, I. M., Adler, A. I., Neil, H. A., Matthews, D. R., Manley, S. E., Cull, C. A., Hadden, D., Turner, R. C., & Holman, R. R. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. BMJ. 2000; 321(7258): 405–412.

[27]. Van de Laar, F. A., Lucassen, P. L., Akkermans, R. P., Van de Lisdonk, E. H., Rutten, G. E., & Van Weel, C. α-Glucosidase inhibitors for patients with type 2 diabetes: results from a Cochrane systematic review and meta-analysis. Diabetes Care. 2005; 28(1): 154–163.

[28]. Wei, H., Liu, S., Liao, Y., Ma, C., Wang, D., Tong, J., Feng, J., Yi, T., & Zhu, L. A systematic review of the medicinal potential of mulberry in treating diabetes mellitus. The American Journal of Chinese Medicine. 2018; 46(08): 1743–1770.

[29]. Li, Q., Wang, Y., Dai, Y., & Zhou, X. Effect of mulberry leaf extract on blood glucose and insulin resistance in patients with type 2 diabetes mellitus: a meta-analysis. Journal of Ethnopharmacology. 2021; 271: 113878.