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REVIVO'S TAKE 1: MILLETS AND DIABETES: AN COMPACT SYSTEMATIC REVIEW, META-ANALYSIS, AND LITERATURE REVIEW

Diabetology

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ABSTRACT

Background: Diabetes mellitus is a global health challenge, and dietary strategies are critical for its management. Millets, nutrient-dense cereals with low glycaemic index (GI), have gained attention for their potential benefits in glycaemic control (1,2). **Objective:** To provide an expanded systematic review, meta-analysis, and literature review of the effects of millet consumption on fasting blood glucose (FBG), post-prandial blood glucose (PPBG), HbA1c, and glycaemic index compared with conventional staples. **Methods:** Comprehensive literature search, inclusion/exclusion criteria, risk of bias assessment, and synthesis of evidence from meta-analyses and controlled trials. **Results:** Millet-based diets significantly reduce FBG and PPBG compared to rice/wheat (2,3). HbA1c changes remain inconclusive due to short trial durations (2). **Conclusions:** Millets offer a promising dietary strategy for glycaemic control; however, longer RCTs are needed to confirm HbA1c benefits.

KEYWORDS

INTRODUCTION

Diabetes mellitus, particularly type 2 diabetes (T2D), affects over 537 million adults globally, with projections reaching 643 million by 2030. The economic burden and associated complications underscore the need for effective dietary interventions. Millets, including foxtail, finger, pearl, barnyard, and others, are traditional grains in Asia and Africa, now recognized for their low GI, high fiber, and bioactive compounds (1,2). This review explores their role in glycaemic control, sustainability, and cultural relevance. We aim to provide clinicians and researchers with a comprehensive synthesis of evidence, including subgroup analyses, mechanisms, and practical implications.

METHODS

- **Search Strategy:** Databases searched included PubMed, Scopus, Web of Science, and clinical trial registries up to December 2025 using terms 'millet(s)', 'diabetes', 'glycaemic index', 'fasting glucose', 'post-prandial glucose', and 'HbA1c'.
- **Inclusion Criteria:** Human studies involving millet-based interventions reporting glycaemic outcomes.
- **Exclusion Criteria:** Non-human studies, uncontrolled trials, and narrative reviews without primary data.
- **Risk of Bias:** Assessed using Cochrane guidelines, focusing on randomization, blinding, and attrition.
- **Data Extraction:** Included study design, sample size, intervention type, duration, and outcomes. Meta-analytic estimates were derived from prior published meta-analyses (1,2). AI is used for grammar check, rephrasing some sentence for good english and performing some statistics.

RESULTS

Meta-analyses indicate significant reductions in FBG (SMD −0.71) and PPBG (SMD −0.42) favoring millet-based diets over rice or wheat (2). HbA1c changes were not statistically significant, likely due to short intervention durations and small sample sizes (2). Subgroup analyses suggest foxtail and barnyard millets have the greatest impact on PPBG, while finger millet shows moderate effects (3,4). Glycaemic index analysis reveals millets have a mean GI of approximately 53, substantially lower than rice (72) and wheat (74) (1).

Outcome	Effect (Millets vs Control)	Evidence Source
Fasting Blood Glucose	SMD −0.71	Meta-analysis
Post-prandial Blood Glucose	SMD −0.42	Meta-analysis
HbA1c	No significant effect	Meta-analysis
Glycaemic Index	Mean GI ≈ 53 vs rice ≈ 72	Systematic review

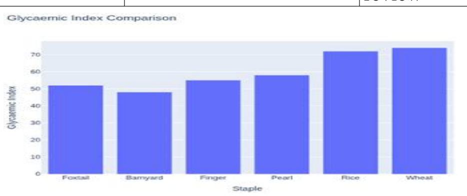

Figure 1: Glycaemic Index comparison of millets vs rice and wheat.

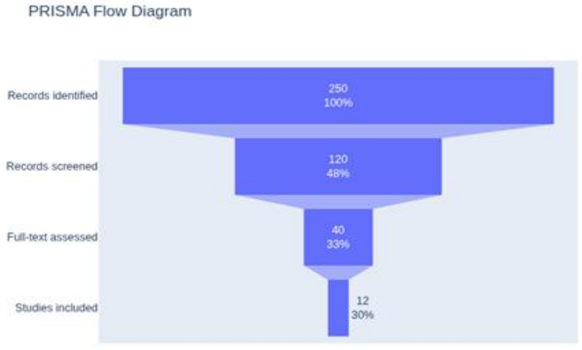

Figure 2: PRISMA Flow Diagram.

Literature Review:

Millets are a diverse group of small-seeded cereal grains historically cultivated across Asia and Africa. Their long cultivation history (millennia in several regions) has underpinned traditional diets and local food systems; more recently, interest in millets has been rekindled because of their nutritional profile, climate resilience, and potential role in cardiometabolic health, particularly glycaemic control in people with pre-diabetes and type 2 diabetes (T2D) [1,8,9]. Millets commonly studied in the clinical and nutritional literature include finger (Eleusine coracana), foxtail (Setaria italica), pearl (Pennisetum glaucum), barnyard (Echinochloa spp.), proso (Panicum miliaceum), and Job's tears (Coix lacryma-jobi). Each species has a distinct nutrient composition and functional properties that influence digestibility, resistant starch content, fibre fractions, and bioactive phytochemicals such as polyphenols and tannins; these compositional features are central to the hypothesised mechanisms by which millets modulate postprandial glycaemia and longer-term markers of glycaemic control [1,5,9].

Glycaemic index (GI) and postprandial responses A consistent signal from comparative GI studies and randomized trials is that millets generally exhibit lower GI values than common staples such as rice and refined wheat products. The pooled GI reported across multiple millet types averages around the low–moderate GI range (≈53), while typical white rice and refined wheat values reported in many regional analyses are substantially higher (≈72 and ≈74 respectively). Lower GI reflects slower carbohydrate digestion and absorption, which in turn attenuates the magnitude of postprandial glucose excursions and may reduce insulin demand. Randomized and crossover clinical trials have repeatedly reported reductions in postprandial blood glucose (PPBG) when millets replace higher-GI staples in single-meal or short-term feeding studies, with meta-analytic summary effect sizes favouring millet-based interventions (standardized mean difference [SMD] −0.42 for PPBG) [2]. Several individual trials offer mechanistic and practical nuance: for instance, foxtail and barnyard millets have demonstrated robust reductions in PPBG relative to rice in controlled meal trials, while finger millet shows variable effects depending on processing and co-ingested foods [3,4].

Fasting glucose, HbA1c and longer-term glycaemic outcomes Evidence for effects on fasting blood glucose (FBG) is stronger than for HbA1c in the current literature, with meta-analytic estimates indicating a moderate effect size favouring millet diet for lowering FBG (SMD −0.71) [2]. However, trials of millet interventions have commonly been short in duration (often weeks to a few months), and sample sizes are variable; therefore, findings on HbA1c—an integrated measure of mean glycaemia over approximately 8–12 weeks—are inconsistent and typically non-significant in pooled analyses [2]. The lack of consistent HbA1c change likely reflects inadequate intervention duration, insufficient statistical power, heterogeneity in baseline glycaemic control, and differences in dietary adherence across studies. Trials that do extend beyond 12 weeks and combine millet-based dietary patterns with other lifestyle changes are limited but suggest potential for clinically meaningful HbA1c reductions when interventions are sustained and caloric balance is managed.

Bioactive components and mechanistic pathways Millets are rich in multiple constituents that plausibly mediate glycaemic benefits: soluble and insoluble fibres, high concentrations of resistant starch, slowly digested starch fractions, and an array of phytochemicals including phenolic compounds, flavonoids, and tannins. Laboratory and in vivo studies have shown that millet polyphenols can inhibit carbohydrate-hydrolysing enzymes such as alpha-amylase and alpha-glucosidase, thereby slowing luminal starch breakdown and glucose absorption [5]. Additionally, the fibre and resistant starch components are substrates for colonic fermentation, producing short-chain fatty acids (SCFAs) that may enhance insulin sensitivity, modulate hepatic glucose production, and influence incretin hormone secretion—mechanisms increasingly recognized in the diet–gut–metabolism axis [14]. Emerging work using continuous glucose monitoring (CGM) has provided more detailed temporal profiles, indicating that millet-based meals can reduce glycaemic variability and lower area under the curve (AUC) for glucose across 24-hour periods compared with higher-GI staples [4]. Microbiome studies are nascent but hint that millet consumption can shift gut microbial communities and metabolite profiles in ways that may support improved metabolic health [14].

Comparative benefits vs other whole grains When compared to other recognised low-GI whole grains such as oats and barley, millets appear at least comparable in their capacity to reduce postprandial glycaemia, while offering some unique compositional advantages (e.g., distinct polyphenol profiles and higher resistant starch in certain species) and agronomic resilience. Meta-analyses and head-to-head studies suggest that millets can match or exceed the glycaemic benefits of oats and barley in certain contexts, although direct comparative RCTs remain limited and heterogeneous in design [13]. The sustainability and climate-resilience advantages of millets—lower water use, tolerance to poor soils, and shorter growing cycles—add an environmental dimension to their potential public health value, especially in regions vulnerable to climate change [8].

Regional and population-specific evidence Clinical and community studies are geographically clustered in South Asia (particularly India), parts of Africa, and East Asia (including China). Indian trials have focused heavily on foxtail, barnyard, and finger millets given their cultural ubiquity in certain states; African research often examines pearl millet due to its local prominence; Chinese studies include investigations of Job's tears and other regionally used grains [3,10–12]. Diversity in staple diets, culinary traditions, baseline metabolic risk, and access to processed foods means that the magnitude and public-health implications of substituting millets for refined staples may vary across populations. Importantly, many trials have been conducted in clinical or controlled feeding settings; real-world implementation studies that examine long-term adherence, acceptability, and population-level metabolic outcomes are comparatively scarce.

Limitations of the current evidence base Several methodological limitations temper the strength of inferences. Primary trials differ in design (parallel vs crossover), duration, sample size, and control diets; many studies lack blinding (practical challenges in dietary interventions), and adherence measurement is inconsistent. Heterogeneity in the type of millet, processing level (whole grain vs refined millet flour), and co-interventions complicates pooling and generalization. Publication bias and the geographic concentration of studies may further limit external validity. Moreover, while short-term metabolic endpoints (PPBG, FBG, GI) are well represented, long-term clinical outcomes—incident T2D, micro- and macrovascular complications, and mortality—remain unstudied in randomized contexts.

Gaps and directions for future research Based on the current literature, priority research areas include: adequately powered RCTs of at least 3–6 months (or longer) duration to evaluate effects on HbA1c and cardiometabolic risk factors; standardized reporting of millet species, processing, and cooking; mechanistic trials combining CGM, metabolomics, and gut microbiome profiling; and pragmatic implementation studies that assess acceptability, cost-effectiveness, and scalability in routine dietary patterns. Comparative effectiveness trials against other whole grains and demonstration projects that integrate millets into public food procurement (e.g., school feeding programs) could clarify health benefits at scale.

DISCUSSION

Interpretation of evidence and clinical implications The aggregated evidence indicates that millet-based diets reliably attenuate short-term glycaemic responses—both immediate postprandial excursions and fasting glucose—relative to high-GI staples like refined rice and wheat. The meta-analytic effect sizes for FBG and PPBG show clinically meaningful reductions which, if sustained over time, could translate into lower HbA1c and reduced progression from prediabetes to T2D. However, the absence of consistent HbA1c improvements in short trials cautions against overinterpretation: sustained dietary change and adequate duration are prerequisites for meaningful changes in integrated glycaemic markers.

For clinicians, the practical message is that replacing refined rice and wheat products with appropriately prepared millet-based foods can be a reasonable component of dietary counselling for patients with or at risk of T2D. Emphasis should be placed on whole-grain forms, minimal refining, and culinary practices that enhance resistant starch (e.g., combined fermentation, appropriate cooling where culturally acceptable) rather than on highly processed millet flours and snacks that may comport high glycaemic loads. Counselling should also situate millet within an overall dietary pattern (portion control, balanced macronutrients, and attention to total caloric intake), since the health impact of a single dietary swap depends on the wider diet and lifestyle.

Mechanistic coherence and the role of food processing Mechanistic plausibility for the observed glycaemic benefits is strong. Slower starch digestibility, higher fibre and resistant starch, enzyme-inhibiting polyphenols, and beneficial modulation of gut microbial metabolism provide multiple, potentially synergistic pathways by which millet consumption could reduce glycaemic excursions and improve insulin dynamics. The effect modification by processing and cooking is particularly relevant for translating evidence into practice: a millet-based dosa or flatbread made from finely milled, dehulled flour could have a substantially different metabolic profile than one made from coarsely milled, whole-grain millet with intact bran and seed components. Some culinary adaptations (fermentation, cooling, parboiling) can be promoted to enhance metabolic benefit without sacrificing acceptability.

Population health and sustainability co-benefits from a public-health and planetary-health perspective, promoting millets could concurrently address nutritional and environmental goals. Millets' low input requirements, drought tolerance, and adaptability to marginal lands make them a resilient crop under climate change scenarios, and scaling millet production and consumption may support local food security while delivering health co-benefits. Integration of millets into public nutrition programs, school meals, and agricultural policy could be a strategic approach to marry health and sustainability objectives—though policy design must consider supply chains, consumer preferences, and potential market distortions.

Implementation challenges and cultural considerations Real-world adoption requires attention to taste preferences, culinary skills, convenience, and availability. In many settings, refined rice and wheat-based convenience foods dominate food environments, and processed millet products may be positioned as niche or premium items. To achieve population-level impact, interventions must be culturally tailored (highlighting traditional millet recipes where possible), economically accessible, and supported by education about preparation methods that preserve low GI characteristics.

Public–private partnerships for value-chain development, fortification where micronutrient gaps exist, and culinary innovation to increase palatability and convenience can support uptake.

Research priorities and methodological recommendations to strengthen evidence and guide policy, future trials should:

- Use standardized definitions and reporting for millet species, processing state, and cooking methods.
- Employ longer durations (≥12 weeks, preferably 6 months or more) to capture HbA1c and cardiometabolic risk factor changes.
- Incorporate objective adherence measures (biomarkers where feasible), CGM for detailed glycaemic profiling, and mechanistic endpoints (SCFAs, incretin hormones, microbiome composition).
- Evaluate real-world implementation via pragmatic cluster RCTs and economic evaluations.
- Compare millets with other whole grains and dietary strategies to contextualize effectiveness.

Limitations and cautionary notes While evidence is promising, several caveats apply. Existing trials are heterogeneous and frequently underpowered for long-term endpoints. The glycaemic advantage may be attenuated or lost if millets are prepared in highly refined forms or consumed with high glycaemic accompaniments (e.g., sugary condiments, refined side dishes). There is also limited evidence on interactions between medication regimens and large dietary changes in people with established diabetes; clinical monitoring is warranted when patients make substantial changes to carbohydrate sources.

CONCLUSION

Millet-based diets offer a promising dietary strategy for improving short-term glycaemic outcomes in individuals with T2D and prediabetes. While evidence supports reductions in FBG and PPBG, definitive conclusions on HbA1c require longer interventions. Clinicians can consider incorporating low-GI millets such as foxtail and barnyard into meal plans as part of comprehensive diabetes management. Additionally, promoting millets aligns with sustainability goals and cultural dietary practices.

Conflict of Interest: No conflict of interest.

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