ORIGINAL RESEARCH

A meta-analysis of Millets' potential for management and reduction of Diabetes Mellitus development

[1]Gagan Gunjan, [2]Kumar Abhishek, [3]Bindey Kumar, [4]Sneha Verma

[1]Assistant Professor, [3]Professor, Department of Medicine, RIMS, Ranchi, Jharkhand, India
[2]Consultant Physician, FORD Hospital, Patna, Bihar, India
[4]Dietician & Diabetes Educator, Ranchi, Jharkhand, India

Correspondence:
Gagan Gunjan
Assistant Professor, Department of Medicine, RIMS, Ranchi, Jharkhand, India

Received: 17 September, 2022 Accepted: 20 October, 2022

ABSTRACT

Introduction: In addition to having a small carbon footprint and the capacity to endure high temperatures with little water, millets are recognised to be very nutrient-dense foods. Millets are well known for helping to treat diabetes because of their low Glycaemic Index (GI). All of the evidence was compiled in this meta-analysis across all millets and cooking/processing methods.

Methods: 39 papers with 111 observations were chosen from the 65 research that were gathered globally to examine GI outcomes. In a meta-analysis, results from 56 trials were examined for fasting, post-prandial glucose level, insulin index, and HbA1c levels. The descriptive statistics make it clear that millets have a mean GI that is 36% lower than that of popular staples like refined wheat and milled rice.

Results: The descriptive, meta, and regression results demonstrated that the millets with the lowest mean GI were Job's tears, fonio, foxtail, barnyard, and teff. A meta-analysis revealed that all millets, with the exception of small millet, which had contradictory data, had considerably lower GI than white rice, refined wheat, conventional glucose, or white wheat bread. In diabetic patients, long-term millet eating significantly decreased fasting and post-prandial blood glucose levels by 12 and 15%, respectively. A significant decrease in HbA1c level was observed in pre-diabetic patients who consumed millets over an extended period of time. Compared to milled rice and refined wheat, less processed millets were 30% more successful at lowering the GI of a meal.

Conclusion: As a result, millets may be utilised to create appropriate meals for diabetic and pre-diabetic patients as well as for persons without diabetes as a preventive measure. Millets can also be helpful in treating and reducing the risk of acquiring diabetes.

Keywords: millets, sorghum, diabetes, glycaemic index, glycaemic response, meta-analysis

INTRODUCTION

Consumption of whole grains, maize, oats, barley, and millets on a regular basis protects against the development of chronic diseases such as cancer, cardiovascular disease, obesity, and diabetes. These grains are known to contain a high concentration of fibre, minerals, vitamins, and phenolic compounds [1]. Eighty-seven percent of diabetes-related deaths occur in poor and middle-income nations where staple meals are less diverse. According to a comprehensive assessment of 19 research publications, millets assist treat diabetes due to their high fibre, antioxidant and polyphenol content [2, 3].

India is the world's largest producer of millets, ranking first in the globe. Millets account for over 58% of global output, however very few Indians are aware of its health benefits and nutritional importance. According to reports, millets are consumed by more than one-third of the world's population, making it an important cereal grain [4]. Millets have been shown in numerous trials to improve glycemic management, decrease fasting and postprandial rises in blood glucose concentration, reduce insulin index and insulin resistance, and lower glycosylated haemoglobin (HbA1c) levels [5, 6].

To serve as a dietary guide for millets, scientific evidence must be compiled to evaluate if studies support the glycemic regulating ability of millets or not, encompassing all types and ways of processing (including cooking). Given the increasing prevalence of diabetes among low and high socioeconomic classes in both developed and developing countries, the purpose of this paper is to conduct a meta-analysis of all studies conducted to test GI, fasting and post-prandial blood glucose concentrations, insulin response, and HbA1c biomarker levels in millet-based diets.

METHODS

The systematic review was carried out by gathering relevant studies on the glucogenic effect of millets in comparison to other staple foods, reviewing the methods used to study this, conducting an analysis to determine the effect of millets in managing diabetes, and conducting a meta-analysis to assess the science-based evidence on millets' ability to reduce insulin concentration, HbA1c biomarker, fasting and postprandial blood glucose concentration, and their effect on managing individuals with diabetes.

The systematic review was carried out between October 2017 and February 2021. The study protocol was registered in the Research Registry, and the systematic review and meta-analysis were carried out using a 27-item PRISMA checklist. The search included all English-language research studies completed between the year 2000 and the fourth quarter of 2021. To discover studies related to the research issue, a detailed search was undertaken utilising search engines PubMed (MEDLINE), Scopus, CAB Abstracts ClinicalTrials.gov, Google Scholar, Web of Science, grey literature, and other Clinical Trial Registries.

INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria for this study include:

(a) Human studies with all varieties of millets were included; (b) in-vitro studies were included but were considered separately.
(b) studies that include GI, fasting, post-prandial glucose levels, insulin index, and/or HbA1c data.
(c) research on normal healthy patients, pre-diabetic subjects, and type 2 diabetic subjects were included.
(d) Peer-reviewed research papers were chosen.
(e) However, review articles, animal studies, and papers in which the entire information was not available, or the procedures were inadequate were excluded.

DATA ANALYSIS

In total, 80 research on the influence of millets on various outcomes in non-diabetic, pre-diabetic, and diabetic patients were collected. Of these, only 65 studies had complete information on either of the five key outcomes (GI, insulin concentration, fasting, post-prandial blood glucose concentration, and HbA1c level). The effects of millets and control samples were compared in several ways, including the effect of consuming millets on five key outcomes in prediabetic, diabetic, and non-diabetic subjects, and comparing the effect of millets on five key outcomes with that of rice (white and brown), wheat (whole and refined), roots and tubers, legumes and others, standard glucose, and white bread.A meta-analysis was carried out to generate data on the effects of millets on GI, fasting, and post-prandial glucose levels when compared to pre-intervention values (baseline) or control samples utilised in the studies, which comprised rice (refined and brown), refined wheat, and maize. It was carried out using the programme R studio version 3.5.1 (2018) to obtain forest plots and estimates of heterogeneity (I 2) in order to assess the randomisation of the investigations.

META-ANALYSIS

The meta-analysis included 65 human studies that used various types and forms of millets to build forest plots for GI (112 observations) and glucose levels at 0 min (fasting blood glucose) and 120 min (post-prandial blood glucose) in normal, pre-diabetic, and diabetic people. The millets were compared to the study's comparable control samples. In forest plots, the heterogeneity of the samples (I 2) and overall test results were obtained, along with p-values to determine the significance of effect. The random effect model and the fixed effect model were both evaluated and utilised to interpret each of the five outcomes.A fixed effect model was employed to interpret the results if heterogeneity was minimal (I 2 50%). Furthermore, where there was only one source of information from the same sample, a fixed effect model was utilised to explain the data.

RESULTS

There were 65 human studies that qualified for the five outcomes (GI, fasting blood glucose, post-prandial blood glucose, insulin level, and HbA1c). Because several writers did research on more than one type of millet, the same author contributed to more than one crop investigated. This resulted in the identification of 99 studies from 65 authors, including 19 studies on finger millet, 20 studies on foxtail millet, 10 studies on sorghum and pearl millet, 7 studies on barnyard millet, 4 studies on little and kodo millet, 3 studies on teff, fonio, and Job's tears, 1 study on proso millet, and 15 studies on a mix of these millets. Aside from that, two in vitro investigations for teff and fonio were included, with 11 observations for GI [7, 8].

The fixed effect model reveals that, with the exception of little millet, the other nine millets had considerably lower GIs when compared to control samples [9]. This hypothesis was helpful in understanding why the fonio and teff samples came from the same source. Only small millet did not have a substantially reduced GI compared to the control samples in both fixed effect and random effect models, out of 11 varieties of millets and one mixed millet evaluated. Because there was no single study that determined the GI of proso millet, it was not included in the meta-analysis. All other studies found that white refined wheat, rice, maize, and glucose had a much lower GI than the control foods studied [9, 10, 11].Long-term millet eating resulted in a decrease in HbA1c levels in all of them. Five research investigated the insulin index, fasting insulin level, and Area Under the Curve of Insulin (AUC) as a co-effect of GI reduction [12, 13, 14, 15, 16]. In the fixed effect model, there was a significant drop in fasting insulin level and insulin index, but no effect on AUC insulin.

DISCUSSION

The majority of the studies found that various varieties of millets presented in varied formats had a glucose-lowering impact when compared to control diets [14, 15]. The results suggest that consuming millet for an extended period of time has a good effect on lowering both fasting and post-prandial blood glucose levels, which are near normal levels for diabetic subjects. While testing following an overnight fast had no influence on fasting blood glucose levels, it did have a substantial effect on post-prandial blood glucose levels. Only two studies determined the insulin index and GI [16, 17].

It should be emphasised that, while Job's tears had a low GI, their insulin index was slightly greater. Job's tears had a lower insulin index when compared to brown rice and Taro, a root vegetable. The co-injection of protein or fat through the meal was attributed by the authors of these research to the insulin response of the food increase. This clearly indicates the importance of exercising extra caution when preparing food for diabetics to ensure it has a low insulin index in order to avoid boosting insulin levels in the blood; high insulin concentration is related with insulin resistance and heart risk.For three months, consuming a millet-based diet increased mean insulin sensitivity from 68.1 ± 4.7 to 88.2 ± 6.0. Ren et al. [18] demonstrated that when foxtail millet was cooked with only water, the insulin index was very low when compared to processed meals, and the insulin index to GI ratio was 1 when compared to processed items. As a result, it was reported as a suitable product for diabetes management.

According to Lakshmi Kumari and Sumathi [19], as well as Abdelgadir et al. [20], the high fibre content in finger millet causes longer gastric emptying or the creation of non-absorbable complexes with carbohydrates in the gut lumen. Thilakavathy and Muthuselvi [21], Pathak et al. [22], and Narayanan et al. [23] have also demonstrated that finger millet has a glucose-lowering impact due to high-soluble dietary fibre in food, which inhibits stomach emptying, glucose absorption after a meal, and digestive enzyme activity. This causes inadequate breakdown of carbs, protein, and lipids, causing absorption to be delayed.Jayasinghe et al. [24] reported that when flour was created using two different processing methods, such as stone milling and industrial milling, the huge particles of wheat produced make starch gelatinization comparatively difficult and slow enzyme assault. This inhibits the release of glucose from food, resulting in a considerable reduction in glycemic reaction.

LIMITATIONS

The majority of the in vivo studies included in the systematic review did not have the recommended number of 8-12 subjects to evaluate GI. Some studies included as few as three individuals, which is a significant constraint; nonetheless, given the low number of studies available for some of the millets and the importance of this information, they were not omitted. Only two trials on pre-diabetic participants were undertaken to establish the link between millet-based meal and diabetes prevention by lowering HbA1c and fasting blood glucose levels from higher to normal ranges.

CONCLUSION

This comprehensive review and meta-analysis confirm that the millets studied have a high potential for dietary control and diabetes prevention. Aside from policy implications, it has implications for nutrition-sensitive agriculture treatments with millets and sorghum, as well as for the spread of the favourable effect of millets and sorghum for glycemic management.

REFERENCES

1. Awika JM. Major cereal grains production and use around the world. In: Awika JM, Piironen V, Bean S, editors. Implications to Food Processing and Health Promotion, Advances in Cereal Science. Washington, DC: American Chemical Society (2011). p. 1–13.

2. Thathola A, Srivastava S, Singh G. Effect of foxtail millet (Setaria Italica) supplementation on serum glucose, serum lipids and glycosylated haemoglobin in type 2 diabetics. Diabet Croat. (2011) 40:23–9.
3. Vetriventhan M, Vania C, Azevedo R, Upadhyaya HD, Nirmalakumari A, Kane-Potaka J, et al. Genetic and genomic resources, and breeding for accelerating improvement of small millets: current status and future interventions. Nucleus. (2020) 63:217–39.
4. Almaski A, Shelly COE, Lightowler H, Thondre S. Millet intake and risk factors of type II diabetes: a systematic review. J Food Nutr Disord. (2019) 8:2.
5. Palanisamy T, Sree R. Efficacy of millets (foxtail, kodo, small, barnyard and pearl millet) varieties on post prandial glycaemic response in patients with type 2 diabetes. Eur J Biomedpharm Sci. (2020) 7:443–9.
6. Poole N, Kane-Potaka J. The Smart Food Triple Bottom Line- Starting with Diversifying Staples Including Summary of latest Smart Food studies at ICRISAT, Agriculture for Development journal, No. 41. Tropical Agriculture Association (2020). p. 21–3.
7. Singh RM, Fedacko J, Mojto V, Isaza A, Dewim M, Watanabe S, et al. Effects of millet based functional foods rich diet on coronary risk factors among subjects with diabetes mellitus: a single arm real world observation from hospital registry. MOJ Public Health. (2020) 9:18–25.
8. Geetha K, Geetha MY, Hulamani S, Hiremath N. Glycaemic index of millet based food mix and its effect on pre diabetic subjects. J Food Sci Technol. (2020) 57:2732–8.
9. Zlowodzki M, Poolman RW, Kerkhoffs GM, Tornetta P, Bhandari M. How to interpret a meta-analysis and judge its value as a guide for clinical practice? Acta Orthopaedica. (2007) 78:598–609.
10. Narayanan J, Sanjeevi V, Rohini U, Trueman P, Viswanathan V. Postprandial glycaemic response of foxtail millet dosa in comparison to a rice dosa in patients with type 2 diabetes. Indian J Med Res. (2016) 144:712–7.
11. Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Non-Randomised Studies in Meta-Analyses. Ottawa: Ottawa Hospital Research Institute (2011).
12. Wolever TMS, Meynier A, Jenkins AL, Brand-Miller JC, Atkinson FS, Gendre D, et al. Glycaemic index and insulinemic index of foods: an interlaboratory study using the ISO 2010 method. Nutrients. (2019) 11:2218.
13. Bell A, Fairbrother M, Jones K. Fixed and random effects models: making an informed choice. Qual Quant. (2019) 53:1051–74.
14. Selvin E, Marinopoulos S, Berkenblit G, Rami T, Brancati FL, Powe NR, et al. Meta-Analysis: glycosylated hemoglobin and cardiovascular disease in diabetes mellitus. Ann Intern Med. (2004) 141:421–31.
15. Atkinson LZ, Cipriani A. How to carry out a literature search for a systematic review: a practical guide. BJPsych Adv. (2018) 24:74–82.
16. Lin MA, Wu MC, Lu S, Lin J. Glycaemic index, glycaemic load and insulinemic index of Chinese starchy foods. World J Gastroenterol. (2010) 16:4973–9.
17. Mohar D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analysis: the PRISMA statement. Open Med. (2009) 3:e1000097.
18. Ren X, Chen J, Molla MM, Wang C, Diaob X, Shen Q. In vitro starch digestibility and in vivo glycaemic response of foxtail millet and its products. Food Funct. (2015) 7:372–9.
19. Lakshmi Kumari P, Sumathi S. Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mellitus (NIDDM) subjects. Plant Foods Human Nutr. (2002) 57:205–13.

20. Abdelgadir M, Abbas M, Järvi A, Elbagir M, Eltom M, Berne C. Glycaemic and insulin responses of six traditional sudanese carbohydrate-rich meals in subjects with type 2 diabetes mellitus. Diabetic Med. (2004) 22:213–7.
21. Thilakavathy S, Muthuselvi S. Development and evaluation of millets incorporated chappathi on glycaemic response in type II diabetics. Indian J Nutr Dietet. (2010) 2:42–50.
22. Pathak P, Srivastava S, Grover S. Development of food products based on millets, legumes and fenugreek seeds and their suitability in the diabetic diet. Int J Food Sci Nutr. (2000) 51:409–14.
23. Narayanan J, Sanjeevi V, Rohini U, Trueman P, Viswanathan V. Postprandial glycaemic response of foxtail millet dosa in comparison to a rice dosa in patients with type 2 diabetes. Indian J Med Res. (2016) 144:712–7.
24. Jayasinghe MA, Ekanayake S, Nugegoda DB. Effect of different milling methods on glycaemic response of foods made with finger millet (Eucenea coracana) flour. Ceylon Med J. (2013) 58:148–52.