Can Millets Mitigate Diabetes?

Diabetes mellitus is among the most common non-communicable diseases plaguing mankind today. Being a lifestyle disorder, the management of diabetes hinges to a large extent on physical activity and diet. The intake of carbohydrates, especially refined carbohydrates with high glycemic index as well as glycemic load, has been implicated in the pathogenesis of obesity as well as diabetes mellitus. Glycemic control in patients with diabetes mellitus requires meals with low to moderate carbohydrate content. However, modern food habits tend towards meals high in carbohydrate content with high glycemic index. In India, wheat and rice are staple grains in most parts of the country. Traditionally, these grains were used in their less refined forms, were high in fiber, and had a low glycemic index. However, with increasing urbanization, wheat flour as well as rice is becoming increasingly refined and low in fiber. With this background, the newfound interest in millets appears to be justified. Millets are small-grained cereals belonging to the grass family; they are annual, warm-weather crops that show abundant growth in Indian weather conditions. India is the largest global producer of millet contributing to more than 40% of global millet production.[1] As these crops require very little water and are easily cultivable, they can be produced in large quantities at a low cost. Therefore, millets can potentially replace the existing refined cereals in Indian diets with a high fiber, low glycemic index, and low glycemic load option.

The beneficial effects of millets, however, appear to be a lot more extensive than simply a reduction in speed and amount of carbohydrate exposure. Animal studies indicate that millets can improve glucose metabolism, favorably impact adipogenesis, and even delay in progression from prediabetes to diabetes.[2,3] Favourable effects on gut microbiota have also been seen in rats fed with millet bran polysaccharides.[4] Protein isolates from foxtail millets have shown potential in glycemia and insulin resistance in streptozotocin-induced diabetic mice.[5] Finger Millets are rich in polyphenols and are acted by gut microbiota, such as *Faecalibacterium*, *Eubacterium*, and *Roseburia*, to produce colonic short-chain fatty acids (SCFAs) which have a beneficial effect on glycemic control.[6] Foxtail millets have been shown to affect PI3K/AKT signalling pathway causing beneficial glycemic effects and reducing inflammation by the NF-κB signalling pathway in diabetic rats.[7] Another study reported that these changes in the PI3K/AKT pathway were effected by altering liver miRNA profile including miRNAs like miR-144-3p_R-1, miR-423-5p, miR-22-5p_R-1, and miR-30a-3p.[8] Even non-alcoholic fatty liver disease and fatty liver amelioration have been reported in animal studies.[9,10] Animal studies indicate that millet may have a role in the prevention of obesity. Millet bran (unfermented/fermented) soluble dietary fibre, when given to mice fed with a high-fat diet, caused inhibition of fat synthesis. This was linked to an inhibition of sterol regulatory element-binding protein-1c gene expression.[11] Polyphenols in millets may also increase GLP-1 secretion in obese mice.[12]

Clinical data on the use of millets is less extensive. A meta-analysis of studies involving short-term administration of various millets found that millet consumption led to lower post-prandial glucose and insulin levels as compared to controls. However, most of these studies reported only a mild reduction in post-prandial glucose.[13] Narayanan *et al.*[14] reported a 44 mg/dl reduction in PPG after consumption of millet dosa as compared to rice dosa. A longer study with 30 days of administration of millets also reported a moderate reduction in blood glucose (23%) and HbA1c (16.5%) along with a 20% reduction in LDL and a similar rise in HDL.[15] Similarly, a trial of millet-based multigrain bread caused a significant reduction in HbA1c, LDL, and insulin levels in patients with type 2 diabetes mellitus.[16] Similar findings were seen with the use of barnyard and foxtail millets also.[17,18]

Long-term millet consumption lowered fasting and post-prandial blood glucose levels significantly in diabetic subjects. A meta- analysis looking at longer-term consumption of millets (up to 4 weeks) reported a 12% and 15% reduction in fasting and post-prandial glucose levels, respectively, in patients with diabetes mellitus. They also reported a significant reduction in HbA1c although the intervention period was not long enough to comment on HbA1c.[19] Although more data is needed to quantify the glycemic benefit arising from millet consumption, available data suggests that the decrease in glucose levels is mild or at most moderate. While small decreases in glucose may not hold clinical importance in most cases, conditions such as gestational diabetes mellitus (GDM), where strict glycemic targets have been prescribed, may provide an optimal avenue for the use of millets. In this issue, Duraiswamy *et al.*,[20] report the results of their RCT in which they administered patients 200 gm of millet-based foods every day for a month. They report a 4.55 mg/dl reduction in post-prandial glucose. Achievement of the 120 mg/dl 2-hour post-prandial target in GDM is always challenging with the risk of hypoglycemia consistently looming in the background. The use of millet in the diet can prove to be a safe intervention to bring the patient closer to this elusive target. However, larger studies with millets in GDM are needed to understand their role in terms of the magnitude of glucose reduction and other aspects.

The beneficial effects of millet have been seen in obesity and dyslipidemia as well. An 8-week trial of extruded sorghum in overweight males in a cross-over design showed a significant

reduction in body fat percentage as compared to extruded wheat consumption.[21] A meta-analysis of millet consumption and its effect on obesity reported a 7% decrease in BMI but most of the studies were short-term in nature.[22] A meta-analysis of 19 studies of millet use for periods ranging from 21 days to 4 months reported significant reduction ranging from 8-10% in various lipid parameters.[22]

Further, several studies indicate the potential role of millet in the prevention of diabetes. Prospective data from the China Kadoorie Biobank suggests that individuals who regularly consumed coarse grains, including millets, had a significantly lower risk of developing diabetes and ischemic stroke as compared to those who never took these grains (the hazard ratios being 0.88 and 0.86 respectively).[23] A significant reduction in HbA1c level (from 6.65 ± 0.4 to 5.67 ± 0.4%) among pre-diabetic individuals ($P < 0.01$) who consumed millets for a long period has also been reported.[19]A study has found that millet muffins as compared to wheat muffins led to lower glycemic peaks and lower insulin levels in patients with prediabetes.[24]

Considering the difficulties in achieving glycemic control in patients with diabetes, there is an urgent need for strategies that are low-cost, safe, do not cause weight gain, and can be easily implemented. Millets are one alternative that appears to fit all these requirements. However, clinical data on millets is still sparse. Although existing data points towards the emergence of a new alternative in medical nutrition therapy for diabetes as well as prediabetes and obesity, there is a need for larger studies with longer follow-ups to clearly understand how millets can be used to manage and prevent diabetes. The challenge lies in first understanding and then harnessing the true potential of millets in metabolic diseases.

Nishant Raizada[1], SV Madhu[1]

[1]Department of Endocrinology, Centre for Diabetes, Endocrinology and Metabolism, University College of Medical Sciences and GTB Hospital, Delhi, India

Address for correspondence: Dr. SV Madhu, Department of Endocrinology, Centre for Diabetes, Endocrinology and Metabolism, University College of Medical Sciences and GTB Hospital, Delhi, India.
E-mail: drsvmadhu@gmail.com

References

1. Ahamed V P A, Joshi A, Mudey A, Choudhari S, Raut J, Ahmed S. Unlocking the potential: Millets and their impact on diabetes management. Cureus 2024;16:e59283.
2. Wang H, Shen Q, Zhang F, Fu Y, Zhu Y, Zhao L, *et al.* Heat-treated foxtail millet protein delayed the development of pre-diabetes to diabetes in mice by altering gut microbiota and metabolomic profiles. Food Funct 2023;14:4866–80.
3. Theodoro JMV, Martinez ODM, Grancieri M, Toledo RCL, Binoti ML, Martins AMD, *et al.* Germinated millet flour (Pennisetum glaucum (L.) R. BR.) improves adipogenesis and glucose metabolism and maintains thyroid function *in vivo*. Food Funct 2021;12:6083–90.
4. Zhang J, Wang W, Guo D, Bai B, Bo T, Fan S. Antidiabetic effect of millet bran polysaccharides partially mediated via changes in gut microbiome. Foods 2022;11:3406.
5. Fu Y, Yin R, Guo E, Cheng R, Diao X, Xue Y, *et al.* Protein isolates from raw and cooked foxtail millet attenuate development of type 2 diabetes in streptozotocin-induced diabetic mice. Mol Nutr Food Res 2021;65:e2000365.
6. Singh V, Lee G, Son H, Amani S, Baunthiyal M, Shin J-H. Anti-diabetic prospects of dietary bio-actives of millets and the significance of the gut microbiota: A case of finger millet. Front Nutr 2022;9:1056445.
7. Ren X, Wang L, Chen Z, Hou D, Xue Y, Diao X, *et al.* Foxtail millet improves blood glucose metabolism in diabetic rats through PI3K/AKT and NF-κB signaling pathways mediated by gut microbiota. Nutrients 2021;13:1837.
8. Deng X, Liang J, Wang L, Niu L, Xiao J, Guo Q, *et al.* Whole grain proso millet (Panicum miliaceum L.) attenuates hyperglycemia in type 2 diabetic mice: involvement of miRNA profile. J Agric Food Chem 2023;71:9324–36.
9. Ghani I, An Y, Qiao Q, He S, Li Z. Polyphenols from foxtail millet improve non-alcoholic fatty liver disease by regulating intestinal microbiome in mice. Foods 2024;13:1683.
10. Park M-Y, Jang H-H, Kim JB, Yoon HN, Lee J-Y, Lee Y-M, *et al.* Hog millet (Panicum miliaceum L.)-supplemented diet ameliorates hyperlipidemia and hepatic lipid accumulation in C57BL/6J-ob/ob mice. Nutr Res Pract 2011;5:511–9.
11. Yang D, Shen J, Tang C, Lu Z, Lu F, Bie X, *et al.* Prevention of high-fat-diet-induced obesity in mice by soluble dietary fiber from fermented and unfermented millet bran. Food Res Int 2024;179:113974.
12. Yuxuan A, Xiaoqin L, Songtao L, Jinmiao T, Xiaxia F, Kaili C, *et al.* Polyphenols from whole millet grain (Setaria italica) alleviate glucose and lipid homeostasis in diet-induced obese mice by increasing endogenous GLP-1. J Sci Food Agric 2023;103:7785–97.
13. Almaski A, Coe S, Lightowler H, Thondre S. Millet intake and risk factors of type 2 diabetes: A systematic review. J Food Nutr Disor 2019;8:1-8.
14. 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.
15. Thathola A, Srivastava S, Singh G. Effect of foxtail millet (setaria italica) supplementation on serum glucose, serum lipids and glycosylated hemoglobin in type 2 diabetics. Diabetol Croat 2011;40:23–8.
16. Sobhana PP, Kandlakunta B, Nagaraju R, Thappatla D, Epparapalli S, Vemula SR, *et al.* Human clinical trial to assess the effect of consumption of multigrain Indian bread on glycemic regulation in type 2 diabetic participants. J Food Biochem 2020;44:e13465.
17. Ren X, Yin R, Hou D, Xue Y, Zhang M, Diao X, *et al.* The glucose-lowering effect of foxtail millet in subjects with impaired glucose tolerance: A self-controlled clinical trial. Nutrients 2018;10:1509.
18. Ugare R, Chimmad B, Naik R, Bharati P, Itagi S. Glycemic index and significance of barnyard millet (Echinochloa frumentacae) in type II diabetics. J Food Sci Technol 2014;51:392-5.
19. Anitha S, Kane-Potaka J, Tsusaka TW, Botha R, Rajendran A, Givens DI, *et al.* A systematic review and meta-analysis of the potential of millets for managing and reducing the risk of developing diabetes mellitus. Front Nutr 2021;8:687428.
20. Duraiswamy M, Jayaseelan V, Ramakrishnan J, Rengaraj S, Krishnamoorthy Y, Kais M, *et al.* Effect of millets once a day on glycaemic control among women with gestational diabetes mellitus in a tertiary care setting – A randomized controlled trial. Indian J Endocr Metab 2024;28:581-8.
21. Anunciação PC, Cardoso L de M, Alfenas R de CG, Queiroz VAV, Carvalho CWP, Martino HSD, *et al.* Extruded sorghum consumption associated with a caloric restricted diet reduces body fat in overweight men: A randomized controlled trial. Food Res Int 2019;119:693–700.

22. Anitha S, Botha R, Kane-Potaka J, Givens DI, Rajendran A, Tsusaka TW, *et al.* Can millet consumption help manage hyperlipidemia and obesity?: A systematic review and meta-analysis. Front Nutr 2021;8:700778.
23. Yang J, Du H, Guo Y, Bian Z, Yu C, Chen Y, *et al.* Coarse grain consumption and risk of cardiometabolic diseases: A prospective cohort study of Chinese adults. J Nutr 2022;152:1476–86.
24. Almaski A, Coe S, Lightowler H, Clegg ME, Thondre PS. Finger millet-based muffin decreases insulin response in individuals with prediabetes in a randomised controlled trial. Br J Nutr 2022;129:1–10.

Access this article online

Quick Response Code:

Website: https://journals.lww.com/indjem/

DOI: 10.4103/ijem.ijem_514_24

How to cite this article: Raizada N, Madhu SV. Can millets mitigate diabetes? Indian J Endocr Metab 2024;28:551-3.