Millets as a Substitute to Wheat-Based Staple Diet for Diabetic Patients

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Introduction

Due to sedentary lifestyle, unhealthy diets, and obesity; incidences of diabetes mellitus are increasing rapidly among adults and geriatric population. It is globally one of the fastest-growing metabolic disorders. According to the IDF (International Diabetes Federation), roughly 537 million adults were suffering from diabetes in 2021, and the number is expected to rise to 783 million by 2045 (Sun et al., 2022). Dietary modification plays a major role in the prevention and management of diabetes specially type-II diabetes mellitus and gestational diabetes. Wheat is a commonly consumed staple grain in many countries; however, refined wheat products often have a relatively high glycaemic index, which can lead to sudden spikes in blood glucose levels or glycaemic levels (Saleh et al., 2013). Millets are small-seeded cereal grains that have gained attention as functional foods owing to their low glycaemic index, high dietary fibre content, and presence of bioactive compounds such as polyphenols and antioxidants. These properties make millets beneficial for regulating blood glucose levels and improving metabolic health. Therefore, substituting wheat with millets in daily diets may act as a crucial factor for the management of diabetes (Khan et al., 2025).

Millets with Anti-Diabetic Properties

Dietary interventions are a simple and cost-effective strategy to improve the health and quality of life of individuals at risk of or with type-II diabetes. Consumption of millet and foodproducts developed from millets has been reported in the previous studies quoting that millets can be healthy dietary option alongside being cost effective (Asif, 2014). Different types of millets have an impact on blood glucose levels during fasting and post-meals, as well as plasma insulin resistance in both healthy individuals and people with type 2 diabetes (Saleh et al., 2013). Reduction of blood glucose level were reported in earlier studies where Consuming barnyard millet-based meals resulted in considerably lower glycaemic response (139.2 to 131.1 mg/dl), foxtail millet reduced fasting glucose by 16-19% after 4 weeks, foxtail millet biscuits reduced serum glucose by 6-7% (Ugare et al., 2014; Itagi et al., 2012; Thathola et al., 2010). It has also been reported that millet porridge reduced insulin response significantly (Abdelgadir et al., 2005). Foxtail millet reduced insulin levels after meals (Ren et al.2016). Millets contain protein, fibre, vitamins, minerals, and bioactive substances that can enhance insulin sensitivity by increasing adiponectin levels and decreasing DPP IV action. In addition, they may inhibit α-amylase and α-glucosidase, altering glucose digestion and absorption. Kumar et al., 2025). Sorghum is a millet with high levels of antioxidants and polyphenols. These compounds play a role in regulating glucose metabolism and reducing oxidative stress associated with diabetes (Taylor & Emmambux, 2008). Sorghum contains resistant starch and tannins that slow carbohydrate digestion and absorption, resulting in lower blood glucose spikes after meals (Saleh et al., 2013). Finger millet is known for its high fibre and polyphenol content (table 1). It contains slowly digestible starch that helps maintain blood glucose levels and prevents instant spikes after food intake (Saleh et al., 2013). Studies have shown that finger millet-based foods produce a lower glycaemic response compared to wheat-based products, making it suitable for diabetic diets (Devi et al., 2014).

Mechanism of Anti-Diabetic Action of Millets

Millets exert their anti-diabetic effects through multiple physiological mechanisms and owing to presence of certain nutrients in the millets as discussed below:

1. Protein

Millet protein hydrolysates (obtained after 3 hours of hydrolysis) inhibited the activity of dipeptidyl peptidase IV (DPP-IV) by 75.72±1.11%, resulting in increased insulin sensitivity, phosphoenol-carboxykinase, and glucose-6-phosphatase (Gu et al., 2021). Heat-treated foxtail millet protein reduced blood glucose levels, IR, and pathogenic microbiota (*Marvinbryantia* and *Dubosiella*), improved insulin sensitivity, glucose tolerance, and increased abundance of probiotics in the stomach (Wang et al., 2023a, 2023b).

2. Fiber

According to Punia Bangar et al. (2022, millets are a good source of fibre, and their hydration produces high-viscose gels that limit the interaction between starch and α-amylases, which could be the cause of sluggish digestion. Cao et al. (2018) showed that dietary fibre from millet bran improved glycaemic management by lowering α-glucosidase activity. Dietary fibre delays carbohydrate digestion and glucose absorption, leading to improved glycaemic control (Saleh et al., 2013).

Table 1: Nutritional composition of various millets and wheats

Grains	Carbohydrate (g/100g)	Protein (g/100g)	Fiber (g/100g)	Fat (g/100g)	Polyphenols (mg/100g)	Reference
Sorghum	72.6	10.4	6.7	3.1	200-1000	(longvah et al.,2017;Saleh et al., 2013; Anitha et al., 2021; Awika & Rooney, 2004; Dykes & Rooney, 2006)
Pearl millet	67.5	11.6	5.0	5.0	72-136	(Saleh et al., 2013; Iongvah et al.,2017; Sharma et al., 2021)
Finger millet	72.0	7.3	11.5	1.3	148-589	(Anitha et al., 2021; Saleh et al., 2013; Iongvah et al.,2017; Chandrasekara & Shahidi, 2011)
Foxtail millet	63.2	12.3	8.0	4.3	100-200	(longvah et al.,2017; Taylor & Emmambux, 2008; Anitha et al., 2021; Saleh et al., 2013)
Barnyard	65.5	11.3	10.1	3.9	129	(Iongvah et al.,2017; Saleh et al., 2013; Anitha et al., 2021; Chandrasekara & Shahidi, 2011)
Kodo millet	66.6	8.3	9.0	7.6	133-493	(longvah et al.,2017; Saleh et al., 2013; Anitha et al., 2021)
Proso millet	70.4	12.5	7.2	3.1	80-200	(longvah et al.,2017; Taylor & Emmambux, 2008; Anitha et al., 2021; Saleh et al., 2013)
Little millet	67.0	9.7	7.6	4.7	133	(longvah et al.,2017; Saleh et al., 2013; Anitha et al., 2021)
Wheat	71.2	11.8	12.2	1.5	50	(longvah et al.,2017; Adom & Liu, 2002; Anuratha et al., 2024),

3. Polyphenols and Antioxidants

Millets contain phenolic compounds that reduce oxidative stress and improve insulin sensitivity (Devi et al., 2014). Researchers studied the therapeutic value of millet's bioactive components. Phytochemicals present in millets may have hypoglycaemic effects by inhibiting digestive enzymes such α-amylase and glucosidase, which cause postprandial glucose levels to rise (Krishnan et al., 2022). Oxidative stress can impair insulin signalling, reduce GLUT-4 expression, and trigger inflammatory responses. Oxidative stress plays a critical role in the genesis and progression of diabetes mellitus. While antioxidants reduce oxidative stress and inflammation linked to diabetes, millets also help to control diabetes and its challenges (Li et al., 2021).

4. Gluconeogenesis and Glycolysis Regulation

The signalling pathway phosphatidylinositol 3' -kinase (PI3K/AKT) is critical for glucose homeostasis, glycolysis, and gluconeogenesis control (Wang et al. 2022). Consuming millet activates the phosphoinositide 3-kinase/protein kinase B pathway, which inhibits gluconeogenesis (Fu et al., 2021).

5. Improved Gut Microbiota

A balanced gut microbiome is essential for managing glucose metabolism. Consuming millet alters the gut microbiome and promotes beneficial microbes (Fu et al., 2021; Ren et al., 2021). Gut bacteria create SCFAs, including butyrate which has anti-inflammatory properties and is an essential energy source for colonic epithelial cells (Jia et al., 2017).

Conclusion

As diabetes mellitus is increasing rapidly among the adults globally, modification of diet can play an important role in management and prevention of it. Inclusion of millets in daily diet as they contain high dietary fibre and bioactive compounds such as polyphenols and antioxidants can help in regulation of blood glucose level and metabolic health. Reduction of blood glucose was reported in earlier studies where consuming millet-based meals resulted in considerably reduced fasting glucose, and reduced serum glucose. Therefore, incorporating millets as a substitute for wheat-based staple food can serve as an effective substitute for wheat-based staple diet. Millets have anti-diabetic effects by inhibiting carbohydrate-digesting enzymes (α-amylase and αglucosidase), modulating the PI3K/AKT signalling pathway, improving gut microbiota composition, and producing short-chain fatty acids. Their high fibre content slows glucose absorption, while antioxidants reduce oxidative stress and inflammation linked to diabetes. Overall incorporating millet into daily diet can be cost-effective, nutritionally enhancing, and practical method for managing and preventing diabetes.

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