

Impact of Millets on Type 2 Diabetes



Largest systematic review shows millets reduced the risk of developing type 2 diabetes and were useful for managing type 2 diabetes

Smart Food
brief #5

NOTE: Millets are broadly defined to include sorghum

Type 2 diabetes “is the greatest epidemic in human history. It has affected the greatest numbers; it has had the greatest cost.”¹

THE STUDY

The largest ever systematic review of studies published in scientific journals that were conducted on millets and their impact on diabetes.

This included:

- ⇒ 80 studies on humans from 11 countries of which 65 were eligible for both meta-analysis and regression analysis, and included about 1,000 people studied
- ⇒ Diabetic, pre-diabetic and non-diabetic individuals
- ⇒ 11 types of millets, with various processing.



RESULTS

Millets were shown to reduce the risk of developing type 2 diabetes and helped manage type 2 diabetes

Impact on diabetes ^a

Consumption of millets had the following impacts:

- ⇒ For diabetic individuals: **blood glucose levels were lowered** by 12% and 15% for fasting and post-meal respectively. Individuals' **blood glucose level went from diabetic to pre-diabetic level**^c
- ⇒ For diabetic individuals: HbA1c (blood glucose bound to hemoglobin) was lowered by an overall average of 15%^d
- ⇒ For pre-diabetic individuals: **HbA1c was lowered** up to 17% and individuals' **HbA1c level went from prediabetic to normal status**^e

Note: based on long-term studies, 7 days to 2 years; the majority being 3-4 months duration

Glycemic Index (GI) ^b

All cooking methods raised the GI level millets, however:

- ⇒ **The mean GI of millets across all cooking methods is low: 52.7 ± 10.3**
- ⇒ 36% lower than milled rice and wheat (refined and whole grain)^f
- ⇒ 14-37 lower GI than maize
- ⇒ Millets boiled in water: have a low GI; lower than rice or maize
- ⇒ Millets cooked with other ingredients added have a medium GI; lower than wheat and rice

Note: Low GI is <55; Medium GI is 55-69

(a) Based on 21 studies that were eligible for meta-analysis. Overnight studies were not included. Long-term studies are important as the body can often adapt to foods over time and be less responsive. (b) Based on 39 studies, that were eligible for meta-analysis, to determine the GI of millets vs that of rice, wheat and maize. A range of processing methods (boiled, steamed and baked, some whole grain millets, some decorticated and some unspecified) were included. (c) From 134.0 mg/dl to 117.9 mg/dl for fasting and from 202 mg/dl to 172 mg/dl for post-meal (dl=decilitre). (d) from 8.1 ± 1.0% to 7.0 ± 1.4%. (e) from 6.6% ± 0.4 to 5.6% ± 0.4 % (f) GI of milled rice is 71.7 ± 14.4 and wheat (refined and whole grain) is 74.2 ± 14.9.

ABOUT DIABETES

- ⇒ 420 million people have diabetes. ²
- ⇒ “In 2019, an estimated 1.5 million deaths were directly caused by diabetes, and 2.2 million from diabetes and high blood sugar level.” ³
- ⇒ Diabetes is increasing in all regions of the world. India, China and USA have the highest numbers of people with diabetes. Africa has the largest forecasted increase of 143% from 2019 to 2045. ⁴
- ⇒ People “with a background of lower socioeconomic status have been proven to have more incidences of diabetes. This is not only in resource-poor countries but also in rich countries.”⁵
- ⇒ Diabetes was responsible for an estimated \$ 760 billion in health expenditure in 2019 ⁶

What is diabetes

Diabetes is a chronic disease characterized by elevated levels of blood glucose (or blood sugar). The most common is type 2 diabetes, resulting from the body’s ineffective use of insulin, and accounting for about 90% of diabetes incidences. The type of food consumed plays a key role in diabetes along with exercise, smoking and obesity.

There is a growing global diabetes epidemic

- It is estimated that there will be a 51% surge in diabetics globally by 2045, from 463 million in 2019 to 700 million in 2045. ⁷
- Since 2000, deaths have risen 70%. ⁸

Impact from COVID-19: People who are diabetic are more vulnerable to becoming severely ill or dying from COVID-19. Around 50% of countries report disruption of services to treat diabetes and its complications due to COVID-19. ⁹

“Diabetes risk through epigenetic changes can be transmitted intergenerationally, thus creating a vicious cycle that will continue to feed the diabetes epidemic.”¹⁰

The dangers of diabetes

“Diabetes is one of the leading causes of death in the world. In 2019, an estimated 1.5 million deaths were directly caused by diabetes, and 3.7 million from diabetes and high blood sugar level.” ¹¹

“Diabetes is a major cause of blindness, kidney failure, heart attack, stroke and lower limb amputation.” ¹²



1,10: Zimmet P, 2017, Diabetes and its drivers: the largest epidemic in human history?, [Clinical Diabetes and Endocrinology](#).

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3, 11,12: [World Health Organization](#), 2021, Fact Sheet – Diabetes

4: [International Diabetes Association](#), 2019, IFD Diabetes Atlas

5: Shaikh, A and Kumar K, 2017, Diabetes and poverty: A primer for resource poor countries, [Journal of Social Health and Diabetes](#)

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9: [World Health Organization](#), Accessed 2021, Diabetes, webpage

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POLICY RECOMMENDATIONS

1) Design policies and incentives to diversify staples with millets

This wide study has shown that millets have a lower GI than the main staples. Hence, a strategy to diversify staples with millets could manage and reduce the risk of type 2 diabetes. Given that the staples are typically 70% of the plate, across areas like Asia and Africa, diversification of staples could have a major impact.

This is further supported by the fact that millets are a smart food: not only 'good for you' (with good to high levels of many essential nutrients like iron, zinc, calcium and protein) but also 'good for the planet' and 'good for the farmer', i.e., environmentally sustainable, climate-smart, with a lower carbon footprint. Therefore, they should also be part of solutions for reforming the food system. This will help contribute to a range of UN Sustainable Development Goals such as Zero Hunger, Good Health and Well-being, Responsible Consumption and Production, and Climate Action.

The Smart Food initiative advocates an approach to diversify staples with millets by driving consumer demand for millets and supporting the development of value chains for millets from farm to fork.

To achieve this, policy could provide support for:

- awareness campaigns about millets
- low-GI products made with millets
- a level playing field for millets or incentives to grow and eat millets
- biofortified millets, that includes GI levels
- sustainable millet production based on agroecology principles.

2) Incorporate millets into meals designed for diabetics or people with a high risk of being diabetic

The study supports the use of millets for managing and reducing the risk of diabetes. Understanding the effect of different forms of cooking and processing of millets on their GI will be important.

NOTE: There is no one cure for type 2 diabetes, and it requires a lifestyle change, and diet is one of the most effective ways to control the disease.

RESEARCH PRIORITIES

1) One major diabetes study covering all types of millets and processing and using consistent testing methodologies

A large number of studies on millets and diabetes have been conducted by a wide range of research organizations with different millets, forms of cooking and testing methods. More individual studies will always be helpful on the prevention and management of type 2 diabetes. However, the greatest value would be one major study covering:

- all the types of millets and range of varieties
- all major main forms of cooking/processing
- using whole grain and different levels of refinement
- using consistent testing methodologies.

2) Studies on other types of millets that have not yet been widely studied

The types of millets most in need of further detailed studies are:

- Proso millet, which was not included in any of the GI studies but included in fasting and post-meal blood glucose level studies
- Little millet, which showed a wide variation in the results of different studies
- Browntop and guinea millet were not included in any studies.

3) Developing a better understanding of the impacts of poverty on diabetes and vice versa

This should be understood in urban and rural areas and through a multi-dimensional poverty lens.

4) Developing better understanding on diversification of staples and impacts on the UN Sustainable Development Goals (SDGs)

No single solution will solve a complex problem like diabetes. Also, all solutions should be designed understanding their wider impacts within the complex system they are part of. Food system solutions that ensure a positive 'smart food triple bottom line' of being good for you, planet and farmer, will be important. Diversification of staples will impact all these areas and needs to be understood holistically to make informed decisions.

THE STUDY- IN MORE DETAIL

Article:

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⁷ National Technical Board of Nutrition, Government of India (GoI), India.

Scientists and professionals from 7 organizations across 4 countries undertook the largest-ever systematic review of studies in scientific journals conducted on millets and the impact on diabetes. This included:

- 80 studies on humans, of which 65 were eligible for meta-analysis (392 experiments) and a regression analysis (267 experiments)
- 39 studies to analyze GI outcomes using meta-analysis (with 1,093 people and 111 experiments) and regression analysis (267 experiments)
- 56 studies on overnight fasting (1,278 people, 109 experiments) and post-prandial i.e., post-meal (1,179 people, 102 experiments).
- 21 long-term studies on: fasting (with 942 people, 28 experiments), post-meal (with 727 people, 18 experiments), insulin (with 271 people, 17 experiments) and HbA1c (with 486 people, 7 experiments) outcomes in a meta-analysis.
- Undertaken on diabetic, pre-diabetic and non-diabetic individuals.

11 Types of millets used in the 65 studies that were analyzed

Type of millet	# of Studies*
Foxtail millet	20
Finger millet	19
Sorghum	10
Pearl millet	10
Barnyard millet	7
Little millet	4
Kodo millet	4
Teff	3
Fonio	3
Job's tears	3
Proso millet	1
Mixed millets	15
Browntop millet	0
Guinea millet	0
Total	99

*Some studies include more than one millet

The 65 human studies were from 11 countries

Country	# of studies
Sudan	1
Nigeria	2
Tanzania	1
Ethiopia	1
Indonesia	3
Sri Lanka	1
India	48
China	4
Canada	1
USA	1
UK	2
Total	65

Impacts of processing on GI³

All cooking methods raised the GI level; however, even after cooking, millets still had on average a low GI.

- ⇒ **Millets boiled in water: have a low GI, lower than that of rice or maize.**
- ⇒ **Millets baked with other ingredients added: have a medium GI, lower than that of wheat and rice.** (Extra ingredients included e.g., oil/fat and the products were cooked in a pan or in an oven: e.g., dosa, chapati, roti, khakra, bhakri, bread loaf)
- ⇒ **Millets steamed with other ingredients added and most fermented: have medium GI; and lower than that of rice.**

(This included pressure cooking and products like idli, dhokla and steam cooked bread)



Glycemic index (GI) based on different cooking methods (and using meta-analysis)

Cooking method and ingredients	# of studies	GI mean ± SD
Boiling in water and no other ingredients added This included grain boiled like rice or grain/flour boiled like porridge. Studies with other ingredients added were not included e.g., upma, kitchree, noodles and sweets.		
Millet (can be dehusked, whole or polished – not always specified)	39	52.1 ± 3.9 LOW
Rice (typically milled – not always specified)	9	63.1 ± 10.7 MED
Maize (flour)	5	58.8 ± 18.9 MED
Baking with other ingredients added This may include oil/fat and cooked in a pan or in an oven: including dosa, chapati, roti, khakra, bhakri, bread loaf.		
Millet	67	57.9 ± 15.3 MED
Wheat (a combination of whole grain and refined)	20	62.7 ± 22.7MED
Rice	8	69.3 ± 14 MED
Steaming with other ingredients added This may include pressure cooking, and most are fermented e.g., idli, dhokla and steam cooked bread.		
Millet (removing one study that was an outlier)	12	65.9 SD 24.1 MED
Rice	5	75.7 ± 16 HIGH

Glycemic index (GI) by type of millet

GI of millets	Type of millets
Low GI (<55%)	Job's tears, fonio, foxtail millet, barnyard millet and teff
Medium GI (55-69%)	pearl millet, finger millet, kodo millet, little millet and sorghum



There is no easy solution to diabetes and it requires a lifestyle change, and diet is a very important part of this. This study provides one part of the solution useful for individuals and governments. How we use this and implement it into programs needs careful planning.

Dr Hemalatha

Director, National Institute of Nutrition (NIN)



This study has also identified the gaps in information and it would be of great value to have an international collaborative approach to systematically study all types of millets and every form of processing them to identify their impact on diabetes.

Dr Devraj J. Parasannanavar,

Co-author, Scientist, National Institute of Nutrition (NIN)



Milletts are traditional foods consumed in India. Use of locally available millets as dietary diversification coupled with good lifestyle modifications would help reduce not only Type II diabetes but also gestational diabetes.

Professor Kowsalya Subramaniam

Co-author, Registrar, Avinashilingam Institute for Home Science and Higher Education for Women (deemed to be university)



Additional attention to our health has been accelerated due to COVID-19 and diabetics are even more vulnerable to the virus. Our diets play a critical role and if we could bring millets back as a major part of our diet, we would not only help in controlling diabetes, but we would also be adding important nutrients to our plate.

Dr Raj Bhandari

Co-author, Medical doctor, Rep. on the Indian National Technical Board of Nutrition



Now we have strong proof that diversifying our diets with millets can help in prevention and management of diabetes and its complications. India urgently needs solutions to reverse the dangerous growing trend of diabetes and millets is one of the solutions we should be promoting.

Dr Ananthan Rajendran,

Co-author, Scientist, National Institute of Nutrition (NIN)



Milletts are climate-smart and nutritious; and there are opportunities to develop a wide range of products with millets, ranging from pancake mix to soups, energy bars, breakfast cereals, health shakes and more. This could be a triple win for the farmers, industry and consumers.

Ms Joanna Kane-Potaka

Co-author, Assistant Director General, ICRISAT, & Executive Director, Smart Food



Nutrition and health benefits of millets can vary significantly by variety and so we need to design solutions taking the variety into account. It is also important to breed better varieties, not only for yield but also understanding and selecting by glycaemic index as well as micronutrients.

Dr Vetriventhan Mani

Senior Scientist (Genetic Resources), ICRISAT



“The rapidly accelerating threats of climate change and global health crises, including obesity and diabetes, require everyone to pull together in action. The partnership between ICRISAT and the University of Reading is doing exactly this, bringing together our world leading expertise in human nutrition with ICRISAT’s long established role as a leader in agricultural research for rural development.”

Professor Paul Inman
Pro-Vice-Chancellor (international)
University of Reading



“The global health crisis of undernutrition and over-nutrition coexisting is a sign that our food systems need fixing. Greater diversity both on-farm and on-plate is the key to transforming food systems. On-farm diversity is a risk mitigating strategy for farmers in the face of climate change while on-plate diversity helps counter lifestyle diseases such as diabetes. Millets are part of the solution to mitigate the challenges associated with malnutrition, human health, natural resource degradation, and climate change. Trans-disciplinary research involving multiple stakeholders is required to create resilient, sustainable and nutritious food systems.”

Dr Jacqueline d'Arros Hughes
Director General at ICRISAT



“Awareness of this ancient grain is just starting to spread globally, and our review shows millets having a promising role in managing and preventing type 2 diabetes. In the largest review and analysis of research into different types of millet compared to other grains such as refined rice, maize and wheat we found that millets outperform their comparison crops with lower GI and lower blood glucose levels in participants.”

Professor Ian Givens
Co-author of the study and Director,
Institute of Food, Nutrition and Health,
University of Reading



“No one knew there were so many scientific studies undertaken on millets’ effect on diabetes. These benefits were often contested, and this systematic review of the studies published in scientific journals has proven that millets keep blood glucose levels in control, reducing the risk of diabetes, and has shown just how well these smart foods do it.”

Dr S Anitha
Lead author and a Senior Nutrition Scientist,
ICRISAT



“Millets are grown on all inhabited continents, yet they remain a ‘forgotten food’. We hope this will change after 2023, when the world observes the United Nations declared International Year of Millets, and with studies like this that show that millets outperform white rice, maize and wheat.”

Ms Rosemary Botha
Co-author, International Food Policy Research
Institute (IFPRI)



“Millets in Japan are an ancient grain and now almost a ‘forgotten food’. There could be significant positive health benefits if we promoted modern foods with millets, diversified our staple food, even cooking millets mixed with rice. This can have health and business opportunities for Japan.”

Dr Takuji W Tsusaka,
Co-author, Kobe University, Japan

ABOUT MILLETS

'Millet' is a common term to categorize small-seeded grasses that are often called dryland cereals. There are 12 grasses most commonly referred to as millets. Sorghum is also considered a millet in some countries.

Millets are termed a **smart food** because they fit the criteria of being good for you, planet and farmer.

Millets are highly nutritious and fulfil some of the biggest health needs; have a low carbon footprint, survive in high temperatures and with very little water. They are often the last crop standing in times of drought, are climate-smart and a good risk management strategy for farmers. They have multiple uses, from food, feed and fodder, to brewing and biofuels.



Nutrition study series

This study is part of a series that has been worked on for the last four years under the Smart Food initiative and will be progressively released in 2021, including systematic reviews on the impacts of millets on:

- Diabetes
- Iron deficiency anemia
- Managing lipid profile (cholesterol, obesity, hypertension and cardiovascular disease)
- Calcium deficiencies and requirements

As part of this, ICRISAT and the Institute for Food Nutrition and Health at the University of Reading have formed a strategic partnership to research and promote the Smart Food vision that our diets become healthier, more sustainable on the environment and good for those who produce it.

Smart Food executive council:

