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Millets (Shree Anna): Nutritional Potential, Climate Resilience and Public Health Relevance

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Abstract: Millets are a diverse group of cereal crops traditionally cultivated in the drylands of Asia and Africa. In India, they are increasingly promoted as **Shree Anna**, reflecting their nutritional, agricultural and cultural importance. Pearl millet, finger millet, sorghum and small millets such as foxtail, kodo, little, proso and barnyard millet differ considerably in nutrient composition, agronomic performance and culinary use. Compared with refined rice or wheat products, minimally processed millets can provide greater dietary fibre and selected micronutrients, while certain varieties are particularly rich in iron, zinc or calcium. Meta-analyses suggest that millet-based foods may improve postprandial glycaemia, lipid profiles and iron status. However, the evidence is limited by small samples, short interventions, heterogeneous recipes and frequent substitution of millets for refined cereals, making it difficult to separate millet-specific effects from the broader benefits of whole-grain replacement. Millets are also valued for drought tolerance, short growing periods and adaptability to marginal environments, but they are not universally low-input crops, and yield, processing, storage and market constraints remain important. India, the world's largest millet producer, reported approximately 18 million tonnes of production in 2024–2025 and has used the Shree Anna initiative to promote cultivation, processing, entrepreneurship and consumption. Public health policy should avoid presenting millets as medicinal "superfoods." Their greatest value lies in diversifying cereal consumption, strengthening climate-resilient food systems and supporting dryland livelihoods. Future priorities include biofortification, improved processing, consumer-oriented product development, public procurement, rigorous clinical trials and safeguards against converting millets into expensive, ultra-processed foods.

Keywords: millets; Shree Anna; nutrition security; climate-resilient agriculture; diabetes; food systems.

INTRODUCTION

Millets are a heterogeneous group of small-seeded cereals cultivated for food, fodder and animal feed. Major millets include pearl millet and finger millet, while foxtail, kodo, little, proso, barnyard and browntop millet are generally grouped as small or minor millets. Sorghum is botanically distinct but is frequently included in policy and nutritional discussions of millets. India's use of the term **Shree Anna**, meaning an honoured or auspicious grain, seeks to restore recognition to crops that historically supported diets and livelihoods across arid, semi-arid, tribal and mountainous regions.

Millets lost dietary prominence in several parts of India as agricultural support, procurement, processing infrastructure and consumer preferences increasingly favoured rice and wheat. Urbanization also increased demand for refined, convenient and standardized foods. Consequently, crops well adapted to local dryland conditions were often reclassified as "coarse cereals," a term that understated their nutritional and ecological relevance.

Global attention increased when the United Nations declared 2023 the International Year of Millets, with the Food and Agriculture Organization serving as lead agency. The initiative emphasized the ability of millets to grow in adverse environments, contribute to diversified diets and create livelihood opportunities for producers.[1]

The renewed enthusiasm is justified, but it has also generated exaggerated claims. Millets are frequently presented as universally low-glycaemic, protein-rich, environmentally superior and capable of preventing multiple diseases. In reality, millet species and varieties differ considerably, and health effects depend on processing, preparation, portion size and the food they replace. A balanced public health assessment must distinguish demonstrated benefits from marketing narratives.

Nutritional Diversity of Millets

Millets primarily provide carbohydrate but also contain protein, fat, dietary fibre, vitamins, minerals and phenolic compounds. Their composition varies according to species, variety, soil, climate, post-harvest handling and milling. It is therefore misleading to assign a single nutritional profile to all millets.

Pearl millet is notable for its potential iron and zinc content, particularly in biofortified varieties. Finger millet is distinguished by relatively high calcium content, much of which is concentrated in the outer layers of the grain. Sorghum and several small millets can provide substantial fibre and polyphenols when consumed in minimally refined forms. Protein content is generally comparable with that of other cereals, but cereal proteins, including those in millets, may be limited in lysine. Millets should therefore be combined with pulses, dairy products, eggs or other protein sources rather than described as nutritionally complete foods.

Most millets are naturally gluten-free and can contribute to diets for people with coeliac disease. However, products must be protected against contamination with wheat, barley or rye during processing and packaging. Gluten-free status also does not make a product inherently healthy; millet biscuits containing refined flour, sugar and fat may remain nutritionally poor.

The public health advantage of millets is clearest when whole or minimally processed grain replaces refined cereals. Dehulling, polishing and extrusion can improve palatability and cooking convenience but may remove fibre, minerals and phytochemicals. Nutritional claims should therefore describe the actual processed product, not the unprocessed grain from which it originated.

Glycaemic Control and Diabetes

Millets are often promoted for diabetes prevention and management. Their fibre, resistant starch, polyphenols and grain structure may slow digestion and glucose absorption. Nevertheless, glycaemic response varies widely by millet type and preparation. Whole-grain porridge, fermented batter, roti, puffed grain and finely milled instant products do not have equivalent metabolic effects.

A systematic review and meta-analysis reported that millet-based foods had a lower mean glycaemic index than refined rice or wheat-based comparator foods and were associated with improvements in fasting and postprandial glucose among people with diabetes or prediabetes.[2] However, the studies included different millet species, processing methods and intervention durations. Many were relatively small, and replacing refined staples with almost any intact whole grain could produce part of the observed benefit.

Millets should therefore be viewed as one option within a balanced diabetes diet rather than a treatment. Portion size, accompanying foods, total energy intake and level of processing remain important. Products marketed as "diabetic-friendly" require particular scrutiny because added sugar, starch, fat or refined millet flour can negate the expected advantage.

Cardiovascular and Metabolic Outcomes

A meta-analysis of 19 studies found that millet consumption was associated with reductions in total cholesterol, triglycerides and low-density lipoprotein cholesterol, together with an increase in high-density lipoprotein cholesterol.[3] The direction of effect is biologically plausible because whole grains can influence satiety, bile-acid metabolism and dietary fibre intake. However, intervention periods were generally short, and recipes, comparator diets and study quality varied.

Evidence for body-weight reduction and blood-pressure improvement is less certain. Millet-based diets may improve satiety when they replace refined foods, but no millet can independently produce weight loss without an overall favourable energy balance. Similarly, cardiovascular claims should be based on complete dietary patterns rather than isolated grain substitution.

The appropriate public health recommendation is dietary diversification: replacing some refined cereal intake with minimally processed millets, pulses and other whole grains. Presenting millets as a pharmacological intervention risks both scientific overstatement and consumer disappointment.

Micronutrients, Anaemia and Biofortification

Iron-rich pearl millet is of particular interest in countries where iron deficiency and anaemia remain common. A systematic review and meta-analysis involving human and laboratory studies found that regular consumption of millet-based foods was associated with improved haemoglobin and iron-related outcomes, especially when higher-iron varieties were used.[4] Fermentation, germination and soaking may improve iron bioavailability by reducing phytate and other inhibitory factors, although effects vary by process.

The findings are promising but require cautious interpretation. Anaemia has multiple causes, including iron deficiency, other nutrient deficiencies, infection, inflammation, haemoglobin disorders and blood loss. Millet promotion cannot replace diagnosis, iron supplementation where indicated, infection control or broader maternal and child health interventions.

Biofortified pearl millet provides a stronger strategy than assuming that every millet variety is iron-rich. Indian research has demonstrated that iron-biofortified pearl millet can improve iron status among populations with high deficiency risk.[5] Crop-breeding programmes should therefore retain both agronomic traits and nutritionally meaningful mineral targets.

Finger millet is frequently promoted for bone health because of its calcium content. The actual amount retained and absorbed depends on variety, milling and processing. Its inclusion may help diversify calcium sources, especially where dairy intake is low, but it should not be described as a substitute for the total dietary and clinical management of osteoporosis.

Antinutritional Factors and Processing

Millets contain phytates, tannins and other compounds that can reduce mineral or protein bioavailability. The term “antinutrient” should not imply that these grains are harmful; many of the same compounds also have antioxidant or other biological properties. Their nutritional significance depends on concentration, total diet and processing.

Traditional methods—including soaking, fermentation, malting, germination and cooking—can improve digestibility, flavour and mineral bioaccessibility. Fermented millet batters used for dosa, idli or traditional beverages are therefore not merely culinary practices but examples of food processing adapted over generations.

Conversely, excessive polishing can remove nutrient-rich outer layers, while high-temperature extrusion and fine milling may increase starch accessibility and glycaemic response. A 2024 review of millet-processing technologies emphasized that processing can improve convenience and safety but may also alter nutritional and functional properties.[6]

Processing research should focus on preserving fibre and micronutrients while reducing cooking time, rancidity and undesirable texture. The choice is not between “traditional” and “modern” processing; the goal is nutritionally intelligent processing.

Public Health Significance

Millets connect nutrition policy with agricultural adaptation, rural livelihoods and environmental sustainability. This is their most distinctive public health value. A food-system intervention that improves dietary diversity while strengthening production in water-stressed regions can produce benefits beyond individual nutrient intake.

In India, millets are relevant to the double burden of malnutrition. Minimally processed grains can contribute fibre and micronutrients, while biofortified varieties may support anaemia-control strategies. At the same time, they can provide alternatives to highly refined cereal products associated with rapidly changing urban diets.

Millets also have cultural significance among tribal and dryland communities. Promotion should not appropriate traditional crops solely for premium urban markets while making them less affordable to populations that preserved their cultivation and culinary knowledge. Public health policy should protect local food sovereignty and ensure that value-chain gains reach smallholder farmers, particularly women and tribal producers.

Table 1. Major millets, nutritional attributes and public health considerations

Millet	Notable nutritional or agronomic feature	Potential public health application	Important limitation	Policy or research priority
Pearl millet (*Pennisetum glaucum*)	Drought tolerance; selected varieties rich in iron and zinc	Dietary diversification and biofortification for populations at risk of iron deficiency	Mineral content and bioavailability vary markedly by variety and processing	Scale quality-assured iron-biofortified seed and monitor biological outcomes
Finger millet (*Eleusine coracana*)	Relatively high calcium; suitable for several fermented foods	Complementary foods and diversified calcium intake	Calcium is reduced by decortication; evidence for clinical bone outcomes is limited	Develop minimally refined, age-appropriate products and measure bioavailability
Sorghum (*Sorghum bicolor*)	Fibre, phenolic compounds and wide dryland adaptation	Replacement for refined cereals and climate-resilient food systems	Some varieties have high tannins and variable protein digestibility	Breed for nutrition, yield and processing quality simultaneously
Foxtail millet (*Setaria italica*)	Short-duration crop; potentially favourable glycaemic properties	Diversification of cereal intake among people at metabolic risk	Evidence is based mainly on small or short-duration interventions	Conduct adequately powered controlled feeding trials
Kodo millet (*Paspalum scrobiculatum*)	Adapted to marginal environments; high fibre in less-refined forms	Tribal and dryland food security	Poor storage may permit fungal contamination; processing infrastructure is limited	Strengthen quality control, storage and local value chains
Little millet (*Panicum sumatrense*)	Short-duration small millet suitable for dry areas	Crop and dietary diversification	Small grain size makes dehulling labour-intensive	Invest in decentralized processing and farmer-producer organizations
Barnyard millet (*Echinochloa* species)	Rapid growth and traditionally used during fasting	Alternative cereal and culinary diversification	"Low-glycaemic" claims vary by preparation	Establish standardized food-composition and glycaemic-response databases
Proso millet (*Panicum miliaceum*)	Short growing season and low water requirement in suitable environments	Climate adaptation and diversification in marginal regions	Limited consumer familiarity and market demand in many areas	Support product development and agronomic research
Millet-based packaged foods	Convenience and potential to increase urban consumption	Wider consumer reach and institutional procurement	May contain refined starch, sugar, salt or saturated fat and command premium prices	Require accurate front-of-pack information and whole-grain composition standards

Millets are not a replacement for pulses, vegetables, fruits, animal-source foods or fortified staples. Food security based mainly on any single cereal remains nutritionally incomplete. Their role should be to diversify rather than merely substitute one cereal monoculture with another.

Climate Resilience and Environmental Claims

Millets are often suited to arid and semi-arid environments because several species tolerate heat, drought and relatively poor soils. Some have short growing periods and can survive rainfall variability better than water-intensive cereals. FAO has highlighted their potential to improve self-sufficiency and reduce dependence on imported grains in climatically vulnerable countries.[1]

However, "climate-smart" should not be interpreted as "climate-proof." Extreme heat, prolonged drought, flooding, pests and degraded soils can reduce millet yields. Different species also have different water, nutrient and management requirements. Comparative environmental claims must consider location, yield, irrigation, fertilizer use, processing and transport rather than relying on generalized crop averages.

Millet cultivation can contribute to resilient crop portfolios, especially in drylands where rice or wheat requires substantial irrigation. Its wider adoption should nevertheless be guided by local agroecology and farmer preferences. Farmers will not sustain cultivation unless yields, procurement, storage, processing and market prices are economically viable.

Global and Indian Policy Context

The International Year of Millets transformed a previously under-recognized crop group into a global food-system priority. Its lasting value will depend on whether countries continue investment in research, seed systems, processing and markets after the promotional year.

India is the world's largest producer of millets. Government data reported production of approximately 180.15 lakh tonnes in 2024–2025 and estimated India's contribution at 38.4% of global production.[7] Rajasthan, Maharashtra and Karnataka remain major producing states, although different millets are cultivated across central, southern, Himalayan and northeastern regions.

The Shree Anna initiative has included support for cultivation, start-ups, research, processing, exports and awareness. The Indian Institute of Millets Research has been positioned as a centre for technical leadership. State programmes, including Odisha's millet initiatives, have additionally linked cultivation with farmer-producer organizations, women's self-help groups, public procurement and nutrition programmes.

Policy must now move beyond festivals and branded products. Sustainable demand requires regular household consumption, institutional use and viable farm-gate prices. Public distribution, school meals, anganwadi services and hospital diets could provide demand, but inclusion should follow local acceptability, reliable supply and menu testing rather than centrally imposed recipes.

Recent Advances

Biofortified millet varieties

Breeding programmes increasingly target iron, zinc and agronomic resilience simultaneously. Pearl millet is among the strongest examples of crop biofortification, with evidence that higher-iron varieties can improve iron status. Future programmes should ensure that nutritional traits remain stable across environments and storage.

Genomics and accelerated breeding

Genomic tools are helping identify traits associated with drought tolerance, nutrient density, disease resistance and grain quality. Because research investment in millets has historically lagged behind rice, wheat and maize, expanded genomic resources could substantially accelerate improvement.

Improved processing and ready-to-cook foods

Extrusion, controlled fermentation, malting, composite flours and shelf-life technologies are increasing convenience. These advances can address the perception that millets are difficult to cook. Yet innovation should preserve whole-grain value and avoid producing premium snack foods with high sugar, salt or fat.

Digital and climate-informed agriculture

Remote sensing, climate advisories and improved weather forecasting may help millet farmers select sowing periods and manage drought risk. Their effectiveness will depend on local extension services, access to seed and whether smallholders can act on the advice.

Renewed culinary research

Chefs, community groups and food enterprises are adapting millets to contemporary diets. Successful mainstreaming will require palatable, affordable foods rather than relying on health messaging alone. Taste, texture, cooking time and familiarity often determine sustained consumption more strongly than nutritional knowledge.

Challenges and Limitations

The clinical evidence remains weaker than promotional claims suggest. Many studies have small samples, short follow-up and poorly standardized interventions. Millet foods differ in species, variety, particle size, fermentation, cooking and accompanying ingredients, limiting direct comparison.

Publication bias is also possible because positive studies may be more likely to appear. Several reviews include studies from a limited number of research groups and settings. Independent multicentre trials are needed.

Nutrient composition varies substantially. Statements that all millets are rich in iron, protein or calcium are scientifically inaccurate. National food-composition tables should include variety- and processing-specific data.

Consumer barriers include unfamiliarity, longer cooking time, inconsistent quality, limited urban availability and higher retail prices. A grain traditionally associated with low-income rural diets is increasingly sold as an expensive lifestyle product. This transition may stimulate markets but can also exclude ordinary households.

Supply-side constraints include lower yield than major subsidized cereals in some settings, labour-intensive processing, inadequate dehulling equipment, storage losses and unstable demand. Without assured procurement and local processing, farmers may not benefit from public promotion.

There are also food-safety concerns. Improper storage can lead to fungal contamination, while fragmented processing markets may lack consistent quality standards. Packaged millet foods require the same regulatory scrutiny as other processed foods.

Future Directions and Policy Priorities

Future research should compare clearly characterized millet foods with realistic dietary alternatives. Trials should report species, variety, processing, particle size, recipe, dose and comparator. Longer studies are needed to evaluate glycated haemoglobin, lipid outcomes, iron status, body weight and acceptability.

India should develop an integrated millet evidence platform linking crop varieties, food composition, processing, clinical outcomes, prices and environmental indicators. Claims used in commercial promotion should be supported by product-specific evidence.

Public procurement can create stable demand but should use decentralized and culturally appropriate models. Locally produced millets should be incorporated into school and community meals where communities traditionally consume them and where processing and preparation capacity exists.

Farmer policy should include improved seed, extension, credit, crop insurance, local dehulling facilities, storage and assured markets. Women's collectives and tribal farmer organizations should participate in value addition and retain a fair share of revenue.

Nutrition policy should prioritize whole or minimally processed millet products. Labelling standards should prevent refined millet snacks from using the health reputation of the grain to obscure high sugar, sodium or saturated fat.

Finally, millet promotion should be evaluated against multiple outcomes: dietary diversity, farmer income, women's participation, water use, yield stability, consumer affordability and health—not production volume alone.

CONCLUSION

Millets deserve renewed attention because they combine nutritional diversity, cultural heritage and adaptation to many dryland environments. Selected varieties can provide meaningful amounts of iron, zinc or calcium, and millet-based diets may improve glycaemic and lipid outcomes when they replace refined cereal foods. The evidence, however, does not support presenting all millets or millet products as universally superior "superfoods."

Their most credible public health role is as part of diversified, minimally processed diets and climate-resilient agricultural systems. Biofortified pearl millet may contribute to iron-deficiency strategies, while finger millet and small millets can expand dietary and crop diversity. These benefits depend on appropriate varieties, processing and food combinations.
India's Shree Anna initiative has created unprecedented policy visibility. The next stage must shift from celebration to institutionalization: stable farmer incentives, decentralized processing, rigorous nutrition research, public procurement, affordable consumer products and transparent food standards.
Millets should neither remain marginalized as coarse grains nor be transformed exclusively into premium urban commodities. Their revival will be successful when they improve the diets and livelihoods of ordinary populations, strengthen resilience in vulnerable farming regions and contribute to a more diverse and equitable food system.

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