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Millets: A sustainable solution for malnutrition among tribal children

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Abstract
Tribal children in India still face serious malnutrition**,** with high levels of stunting, wasting, and being underweight, mainly because they live in poverty, far from cities, and lack proper food and healthcare. In order to address malnutrition in tribal populations, this study explores the potential of millets as a culturally appropriate and sustainable dietary intervention. Due to changes in policy and the growth of subsidised wheat and rice, millets, which were formerly a mainstay of tribal diets, have become less popular. However, their exceptional nutritional profile including high levels of iron, calcium, zinc, dietary fibre, and essential amino acids makes them an ideal solution to address micronutrient deficiencies and "hidden hunger". Millets are also environmentally resilient, requiring minimal water and inputs, making them suitable for marginal tribal farmlands. The paper highlights the traditional significance of millets, their agricultural advantages, and their health benefits for tribal children, particularly in improving growth, immunity, and cognitive function. It further emphasizes the need for policy integration, school-based interventions, community education, and research support to revive millet consumption. Reintegrating millets into public food programs and tribal farming systems can ensure food security, promote ecological sustainability, and improve health outcomes among India's most vulnerable children.

Keywords: Millets, malnutrition, tribal children, poverty, sustainable solution

1. Introduction
Malnutrition remains a significant public health challenge in India, especially among tribal children who experience high levels of stunting, wasting, and underweight compared to the national average. According to the National Family Health Survey-5 (NFHS-5), over 35.6% of children under five in Scheduled Tribe communities are stunted, and 19.9% are wasted, indicating a persistent crisis in nutritional security (MoHFW, 2021) [24]. Multiple socio-economic factors contribute to this burden, including poverty, geographic isolation, low literacy, food insecurity, and limited access to healthcare and sanitation (Anil., 2024) [3]. Studies suggest that tribal communities in remote areas often rely on monoculture diets, with inadequate intake of fruits, vegetables, and protein-rich foods. Furthermore, the problem is made worse by cultural customs, the migration season, and the generations-long pattern of under nutrition. (Kadiyala *et al*., 2014) [20]. Over the past few decades, traditional food systems in tribal regions have undergone rapid transformation. The shift from diverse indigenous grains to polished rice and refined wheat, driven by the Green Revolution and the Public Distribution System (PDS), has led to a reduction in dietary diversity (Nelson *et al*., 2019) [14]. These modern cereals, although high in calories, lack essential micronutrients and dietary fiber, contributing to the rising prevalence of "hidden hunger" or micronutrient deficiencies among children (Weffort *et al*., 2024) [36].
In contrast, millets particularly finger millet (ragi), pearl millet (bajra), little millet, and kodo millet offer a nutritionally superior alternative. Millets are rich in iron, calcium, zinc, magnesium, dietary fiber, and essential amino acids like methionine and lysine, which are often lacking in mainstream cereals (Saleh *et al*., 2013) [32]. For example, finger millet contains 30 times more calcium than polished rice, while pearl millet has nearly 10 times more iron than wheat. Millets have been grown and eaten for ages by tribal populations all over India.

Due to their drought resistance, adaptability to poor soils, and low input requirements, these grains are ideal for the agroclimatic conditions of tribal areas (Verma *et al*., 2018) [35]. Their cultivation and consumption declined due to socio-political marginalization, unfavorable agricultural policies, and the perception of millets as “poor man’s food” (Michaelraj *et al*., 2013) [22]. Millets have gained renewed interest in recent years as part of sustainable nutrition and dietary plans. By designating 2023 as the International Year of Millets, the Food and Agriculture Organisation (FAO) and the Indian government have brought attention to the potential of millets in preventing malnutrition and promoting climate-resilient farming (FAO, 2023) [16]. Several school feeding and community-based nutrition programs have shown promising results when millets are incorporated into children's diets.

This review seeks to explore the potential of millets in addressing the complex problem of malnutrition among tribal children by analyzing their nutritional benefits, historical significance, and scope for integration into national nutrition and agriculture policies.

2. Nutritional profile of millets

Millets are a group of small-seeded grasses that serve as a nutrient-dense, climate-resilient alternative to conventional cereals like rice and wheat. These grains are rich in complex carbohydrates, protein, dietary fiber, essential fatty acids, vitamins, and minerals, making them particularly suitable for improving the diets of undernourished populations, especially tribal children (Saleh *et al*., 2013) [32]. Millets provide slow-digesting complex carbohydrates, which offer sustained energy release ideal for school-going children. Their protein content ranges between 7-11%, depending on the type, and includes essential amino acids like methionine and lysine, often deficient in cereal-based diets (Devi *et al*., 2014) [13]. Millets have a high dietary fibre content (up to 18%) that promotes digestive health, helps in nutrient absorption, and reduces the risk of childhood obesity and type 2 diabetes (Shobana *et al*., 2013) [34]. Millets are significantly richer in iron, calcium, phosphorus, magnesium, zinc, and B-complex vitamins compared to rice or wheat. For instance, finger millet (ragi) contains 344 mg of calcium per 100g, supporting bone development and prevention of rickets in children. Millets also contain polyphenols and antioxidants, which enhance immunity, reduce inflammation, and protect against oxidative stress, factors important for children exposed to infections and environmental stressors (Bheemaiah *et al*., 2024) [7]. All millets are naturally gluten-free, making them ideal for children with celiac disease or gluten intolerance (Saleh *et al*., 2013) [32].

3. Malnutrition Status among Tribal Children in India: India’s tribal communities (Scheduled Tribes) constitute approximately 8.6% of the country’s population, yet they face some of the worst nutrition indicators due to poverty, geographic isolation, limited access to healthcare, and culturally inappropriate food systems (MoTA, 2023) [26]. According to the National Family Health Survey (NFHS-5, 2019-21), the prevalence of stunting among tribal children under five stands at 42%, which is significantly higher than the national average of 35.5%. Wasting is observed in 18.8% of tribal children, while underweight prevalence is at 39.2%, reflecting chronic and acute forms of under nutrition (IIPS & ICF, 2021) [18, 19]. Micronutrient deficits are common, particularly in iron, vitamin A, zinc, and iodine. Iron-deficiency anaemia is linked to low immunity, tiredness, and learning disabilities (Samal *et al*., 2020) [33]. Due mainly to reliance on rice that was subsidised by the PDS, traditional tribal diets, despite their historical diversity, have become monotonous and dominated by cereals, resulting in insufficient consumption of protein and micronutrients. Low dietary diversity has been directly linked to poor growth outcomes in tribal children (Chinnaiyan, 2022) [10]. Tribal populations often live in remote, forested, or hilly terrains, where access to healthcare, clean water, and sanitation is limited. These conditions increase the risk of infections like diarrhoea, which further worsen nutritional outcomes among children (Deb Roy *et al*., 2023) [12]. Low literacy, early marriage, traditional beliefs about food, and limited awareness of nutrition also contribute to malnutrition. Women and children are often the last to eat, and culturally significant foods like millets have been replaced with “modern” alternatives perceived as superior (Raju *et al*., 2015) [30]. Though various government programs like ICDS, POSHAN Abhiyaan and Tribal sub-plan exist their reach and effectiveness in tribal belts remain inadequate. Weak infrastructure, shortage of trained workers, and language/cultural disconnects further reduce program efficiency (MoHFW, 2021) [24].

4. Traditional Role of Millets in Tribal Diets: Millets have been an integral part of the traditional food systems of tribal communities across India for centuries. Known for their hardiness, adaptability, and cultural relevance, millets were historically grown, stored, and consumed by tribal families as staple cereals before the Green Revolution shifted focus to rice and wheat (Bandyopadhyay *et al*., 2025) [5]. Tribal communities across regions such as Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, and West Bengal have traditionally relied on millets like Kodo, kutki, Ragi, and Jowar as dietary staples. These were commonly prepared as roti, Bhat (boiled grain), porridge, and local beverages. Their preparation and consumption are deeply linked with seasonal festivals, rituals, and farming cycles (Aman *et al*., 2024) [2]. Millets were widely cultivated in tribal areas due to their adaptability to dryland and hilly terrains, where mainstream crops like paddy failed. The low-input, rain-fed farming of millets ensured food security even in remote and economically marginalized regions (Yadav *et al*., 2024) [37]. Traditional millet-based foods were often fermented, sprouted, or mixed with pulses, enhancing nutrient bioavailability and digestibility. For example, fermented ragi porridge was commonly given to children and elderly members for its cooling and nourishing properties (Devi *et al*., 2014) [13].

With the introduction of high-yielding varieties of rice and wheat, and Public Distribution System (PDS) support for subsidized rice, the cultivation and consumption of millets sharply declined. This dietary shift, coupled with reduced agricultural diversity, contributed to rising micronutrient deficiencies and hidden hunger among tribal populations. Modernization, urban migration, and assimilation into dominant food cultures have led to the erosion of traditional millet-related knowledge, particularly among the younger generation. This has weakened intergenerational food practices once centered on health, sustainability, and cultural identity (Aman *et al*., 2024) [2].

5. Health benefits of millets for tribal children: Tribal children in India face disproportionately high levels of malnutrition, often due to limited access to diverse foods, micronutrient deficiencies, and poverty-driven dietary insufficiencies (IIPS & ICF, 2021) [18, 19]. Millets, with their exceptional nutritional profile and local availability, can play a transformative role in improving the health and development of tribal children.

- **Addressing Chronic Malnutrition**: Chronic undernutrition, especially stunting and wasting, is prevalent among tribal populations. Millets such as finger millet, pearl millet, and sorghum are rich in protein and essential amino acids, which are crucial for muscle and tissue development in growing children (Devi *et al*., 2014; NIN, 2020) [13].
- **Combating Micronutrient Deficiencies:** Iron-deficiency anemia is one of the most common conditions among tribal children. Pearl millet and little millet, both rich in iron, can significantly improve haemoglobin levels and reduce the risk of anaemia when included in regular diets (Saleh *et al*., 2013) [32]. Calcium-rich finger millet supports strong bone growth and helps prevent rickets a condition often seen in undernourished children in tribal belts (Devi *et al*., 2014) [13].
- **Gluten-Free and Gut-Friendly:** Millets are naturally gluten-free and easy to digest, making them suitable for children with digestive sensitivities or frequent gastrointestinal infections, common in areas with poor sanitation (Shobana *et al*., 2013) [34].
- **Improved Immunity and Disease Resistance:** The high antioxidant and phytochemical content of millets enhances children's immunity and protects them from infections. This is vital for tribal children, who are more vulnerable due to lack of healthcare access and poor hygiene conditions (Chandrasekara *et al*., 2011) [8].
- **Boosting Cognitive Development:** Micronutrients such as zinc, magnesium, and B-complex vitamins, found abundantly in millets, support neurological development, enhance memory, and improve learning capacity key to breaking the cycle of poverty through education (Chaturvedi *et al*., 2021) [9].
- **Satiety and Energy:** Millets provide slow-releasing energy, helping children stay full for longer and reducing the risk of frequent hunger pangs. This improves concentration in school and reduces dependence on unhealthy snacks (Saleh *et al*., 2013) [32].

6. Agricultural Perspective on Millets: Millets have long been recognized as climate-resilient and low-input crops that are highly suitable for rainfed and marginal lands. Their agronomic advantages make them ideal for sustainable farming systems, especially in tribal and arid regions of India (Mukherjee *et al*., 2025) [27]. Compared to rice and wheat, millets require significantly less water and are more tolerant to drought, salinity, and poor soil conditions (FAO, 2021) [15]. These traits position millets as valuable assets for ensuring food and nutritional security in the face of increasing climate uncertainties (ICAR, 2023) [17]. Millets are also well-suited to diverse agro-ecological zones, particularly in dryland regions where conventional cereals fail. They can grow on shallow, low-fertility soils with minimal fertilizer and pesticide inputs, thus reducing the environmental burden and cost of cultivation (Kumar *et al*., 2022) [21]. From a biodiversity standpoint, promoting millets helps preserve agro-biodiversity, as they include a wide range of species such as pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), and little millet (*Panicum sumatrense*). Intercropping these minor millets increases farm resilience and diversity. Additionally, millet farming is labour-intensive, offering rural employment opportunities, especially for tribal women in land preparation, sowing, weeding, harvesting, and value addition (Ranjan *et al*., 2023) [31].

Recent government initiatives such as the “International Year of Millets 2023”, led by India and endorsed by the FAO, have rejuvenated policy focus on millet cultivation. Programs like the National Food Security Mission (NFSM)-Nutri Cereals aim to enhance productivity, ensure MSP, and provide incentives for millet farming (MoAFW, 2023) [23]. However, challenges remain. The expansion of millets is hindered by low market demand, lack of assured procurement, inadequate processing infrastructure, and minimal inclusion in public food systems (Pingali *et al*., 2019) [29]. Addressing these constraints through investment, research, and policy convergence is essential for unlocking the full agricultural potential of millets. Government support through Minimum Support Price (MSP), seed banks, and farmer training programs is crucial to scaling up millet production.

7. Future Perspectives: Millets present a powerful, sustainable approach to addressing hidden hunger a form of malnutrition caused by micronutrient deficiencies that remains widespread among tribal children in India. While efforts to promote millets have begun, their role in public health nutrition still requires strategic, long-term action.

- **Sustainable crop for climate and nutrition:** Millets are inherently sustainable they require less water, grow in arid and rainfed regions, and are resilient to pests and climate shocks. Cultivating millets in tribal belts where conventional crops fail ensures year-round food availability and enhances local food security without overburdening the environment. **Combating hidden hunger with micronutrients:** Millets are rich in iron, calcium, zinc, magnesium, and B-complex vitamins, addressing critical deficiencies responsible for stunting, anaemia, and poor cognitive development in children. Promoting millet-based diets in regions with high Anaemia and Vitamin B12 deficiencies can directly target the root causes of hidden hunger.
- **Inclusion in Anganwadi and School Meals:** Future interventions must focus on incorporating locally available millets (like ragi, jowar, bajra, kodo) into Anganwadi meals and school feeding programs. Introducing millet khichdi, porridge, laddoos, or fortified mixes can ensure tribal children receive balanced, micronutrient-rich diets during their critical growth years.
- **Revival of Traditional Diets with Local Acceptance:** Many tribal communities historically relied on millets. Reviving these traditional food habits through community engagement and culturally acceptable recipes can increase acceptance. Using locally grown millets also reduces dependency on external food supply chains.
- **Policy, Procurement, and Price Support:** There is a need to strengthen millet procurement under the Public Distribution System (PDS) and PM POSHAN. Policies should encourage local sourcing of millets for government nutrition programs and incentivize tribal farmers with Minimum Support Prices (MSP) and training.
- **Community-Based Nutrition Education:** Training on millet nutrition, meal preparation, and kitchen gardening should be part of future initiatives to empower tribal women and Anganwadi workers. IEC (Information,

Education and Communication) tools like posters, radio, or storytelling in local languages can drive change from within.
- **Monitoring and Research:** Robust monitoring systems must be developed to measure the impact of millet-based interventions on nutritional status, school attendance, and health outcomes. Research facilities and local institutions might be very important in this. Promoting millet locally will depend on local empowerment, local consumption, and local production.

By integrating millets into tribal children's diets through sustainable agriculture, nutrition-sensitive policies, and community-driven action, India can take a significant step toward eradicating malnutrition in a culturally respectful and ecologically sound manner.

8. Conclusion

Malnutrition continues to deeply affect tribal children in India, as poverty, isolation, and cultural challenges make it hard for them to get the nutritious food and healthcare they need to grow and thrive. Despite the availability of various food-based and policy-level interventions, tribal communities continue to face high rates of stunting, wasting, underweight, and micronutrient deficiencies. This calls for sustainable, culturally rooted, and nutritionally rich solutions that go beyond conventional food security approaches. Millets emerge as a viable and powerful solution in this context. Their exceptional nutritional profile rich in iron, calcium, protein, fibre and antioxidants can address both macronutrient and micronutrient deficiencies prevalent among tribal children. Moreover, their adaptability to rain fed, low-input, and marginal agricultural ecosystems makes them ideal for tribal regions where conventional crops often fail. Historically, millets were an integral part of tribal diets, deeply embedded in cultural traditions and agro-ecological systems. Reviving their cultivation and consumption not only enhances dietary diversity but also empowers communities by restoring traditional knowledge and promoting local food sovereignty. Government recognition of millets, including the declaration of 2023 as the International Year of Millets, has created momentum for integrating millets into national nutrition and agricultural policies. However, to fully realize the potential of millets in combating child malnutrition, a coordinated and multi-sectoral approach is essential. This includes promoting millet-based meals in Anganwadi centers and school programs, supporting millet farmers through procurement and pricing mechanisms, educating communities through culturally relevant communication, and conducting research to evaluate long-term outcomes.

In conclusion, millets represent more than just a dietary intervention they symbolize a shift toward sustainable, inclusive, and resilient food systems. Their promotion among tribal populations can be a key lever in achieving nutrition security, reducing inequalities, and fostering healthier generations.

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