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Millets and Multigrains: An Environmentally Sustainable Approach to Health, Nutrition and Food Security

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Abstract

In recent years, the Government of India (GOI) has introduced various initiatives to encourage the cultivation and consumption of millets. Despite their well-known nutritional and health advantages, millets and multigrain have yet to become a regular part of traditional daily diets.

Foods made from millets and multigrains present an environmentally sustainable and climate-resilient approach to addressing the growing concerns of health, nutrition, and food security. As resilient crops, millets such as kodo, proso, foxtail, little, pearl, barnyard, and finger millet require minimal water, withstand extreme climatic conditions, and thrive in resource-poor environments. These characteristics position them as a sustainable alternative to conventional staples, which often demand intensive water use and contribute to environmental strain. This study reviews and explores the nutritional significance and role of millets and multigrains in enhancing food security by using secondary data from scientific literature and government reports. The study also presents a nutritious Indian snack developed using a blend of millet and multigrain flours. A traditional Indian sweet snack Shakkarpara was developed by a blend of Amaranth, Foxtail Millets, Sorghum, Finger Millet, and wheat. This value-added sweet snack was formulated and assessed for its nutritional profile, followed by sensory evaluation to determine its overall acceptability. This Sweet dish served as a nutrient-dense, climate-resilient snack that can be widely adopted for both rural and urban populations. The formulation supports broader objectives of improving public nutrition and promoting sustainable dietary choices.

Keywords: Millets, Multigrain, Environmentally sustainable, Healthy and Nutritious.

1. INTRODUCTION

Millets are gaining widespread attention in India and across the world due to their high nutritional value and ability to withstand harsh climatic conditions. Some of the commonly grown millets in India include sorghum, pearl millet, finger millet, foxtail millet, kodo millet, barnyard millet, proso millet, and little millet. These hardy grains not only offer health benefits but also support sustainable agriculture by requiring less water and fewer resources. Encouraging their cultivation and consumption can help achieve several Sustainable Development Goals (SDGs), making them a valuable addition to food security and environmental sustainability efforts.[3][4]

In Nutritional context also millets are rich in protein, dietary fiber, essential minerals, and antioxidants, making them highly beneficial in combating malnutrition, obesity, diabetes, and other non-communicable

or lifestyle related diseases [14]. Their low glycemic index and gluten-free nature further enhance their suitability for diverse dietary needs, particularly in urban populations where demand is increasing [2].

Climate change has disrupted global food production, with rising temperatures, erratic rainfall, and soil degradation posing serious threats to conventional agriculture. Dependence on staple crops such as wheat and rice exacerbate food insecurity due to their vulnerability to climate fluctuations. Multigrain and millets farming offer a viable alternative by enhancing biodiversity, reducing water and input dependence, and improving soil health. India leads global millet production, accounting for 38.4% of the total output worldwide (FAO, 2023).[5][15]

Recognizing their potential to support health, nutrition, and food security, the Government of India has launched multiple initiatives to promote millet cultivation and consumption. The declaration of 2018 as the "National Year of Millets," followed by the United Nations' designation of 2023 as the "International Year of Millets," provided significant momentum. Schemes such as the National Food Security Mission (NFSM), inclusion of millets in the Public Distribution System (PDS), and various state-level millet missions have aimed to revive their production and integration into daily diets. Despite these efforts, major gaps persist. There is a lack of consumer-oriented research focusing on product diversification, especially in the realm of traditional and culturally relevant millet-based recipes. Additionally, the role of millets in contributing to sustainable diets in the face of climate change remains underexplored in practical, culinary, and policy contexts.[16]

Despite these significant benefits, millets and multigrain formulations remain underutilized in mainstream diets. Several barriers contribute to this underutilization: a lack of consumer awareness, limited availability and accessibility in urban markets, perception of millets as "poor man's food," inadequate value chain infrastructure, and insufficient innovation in millet-based product development. Furthermore, the shift in food preferences toward highly processed and polished grains has marginalized traditional food grains like millets.

This study, titled *"Millets and Multigrains: An Environmentally Sustainable Approach to Health, Nutrition, and Food Security,"* seeks to bridge these gaps by reviewing current literature on the nutritional, economic, and environmental benefits of millets. It also investigates the potential of millet-based multigrain combinations in fostering sustainable dietary patterns. A key objective of the research is to analyze existing traditional sweet dishes made from millets and to develop an improved, culturally rooted recipe for *Shakarpara*—a millet-based sweet bar that aligns with modern nutritional needs and taste preferences.

2. METHODOLOGY

2.1 HISTORY OF MILLETS IN INDIA

Agricultural practices in pre-Harappan India were primarily based on indigenous crops adapted to monsoonal climates, though the transition from foraging to settled farming remains somewhat unclear. Evidence from the late Harappan period (circa 2600 BCE) reveals traces of finger millet in North and West India, suggesting early agricultural interactions with Africa. Millets such as pearl millet, sorghum, and finger millet were introduced to India from Africa in ancient times, indicating long-standing transcontinental crop exchanges. Pearl millet was cultivated in Saurashtra by the late third millennium BCE and had reached South India by around 1800 BCE. Sorghum was grown in Punjab between 2300–2000 BCE, while finger millet was a staple in Neolithic Karnataka as early as 2300 BCE. The Yajurveda (c. 1500 BCE) mentions foxtail, proso, and barnyard millets, showing their integration into early Indian

agricultural and dietary systems. By the late Harappan era (1800–1700 BCE), crop diversity increased, likely as an adaptation to climatic shifts. Archaeological findings from Hallur in Karnataka (2000–1000 BCE) show the cultivation of brown top millet, bristly foxtail, and pearl millet during the Neolithic, with finger and kodo millet appearing in the early Iron Age (1200–1000 BCE). Kodo millet was cultivated in northern and eastern India during the Chalcolithic period (1800–1200 BCE) and spread to the south during the Megalithic period (1000–300 BCE), with archaeological traces found in regions such as Maharashtra and Andhra Pradesh. In the Ganga Valley, its cultivation is associated with the Narhan culture (1300–800 BCE). Discoveries at Hulas in Saharanpur further confirm the presence of sorghum and finger millet, underscoring the expansion of crop systems. By the Mauryan period (200–300 CE), the *Arthashastra* referenced kodo millet as *kodrava*, reflecting its established role in diverse farming systems. Pearl millet also found mention in Ayurvedic literature, notably as "Nali" in the *Madanapala Nighantu* (1374 CE). Collectively, these findings emphasize the deep historical roots of millets in India and their significance in early agricultural development and intercontinental crop diffusion.

Despite this, their significance declined post-Green Revolution due to policy focus on high-yielding rice and wheat varieties (Pingali, 2012). In the current context of climate change, growing lifestyle diseases, and food insecurity, millets are gaining renewed attention as sustainable alternatives.

2.2 Production of Millets in India: Current Status

India cultivates millets over 14.6 million hectares, producing approximately 12.5 million tonnes annually, which makes up 7% of the country's total food grain production. Among them, pearl millet has the largest share, grown on 7.1 million hectares with a yield of 10.3 million tonnes. Sorghum is cultivated on 5.7 million hectares, yielding 4.4 million tonnes, while finger millet covers 1.1 million hectares, producing 1.82 million tonnes. Other millet varieties are grown on 0.7 million hectares, contributing 0.4 million tonnes. These crops are valued for both their nutritional benefits and use as animal fodder.

Millets are mostly cultivated during the kharif season, benefiting from monsoon rainfall. In areas receiving more than 800mm of rain, certain millet varieties can also be grown as rabi crops, making use of the moisture retained in the soil for a second harvest in the post-monsoon and early winter period.[1][4]

2.3 Millets: A Step Towards Sustainable Development

Several studies have highlighted the importance of multigrains in ensuring food security and improving nutrition. Research indicates that millets and other traditional grains are drought-resistant, requiring minimal water and chemical inputs compared to staple crops such as rice and wheat. [1][5][9]

Including millets in farming and daily diets can help India tackle major challenges like hunger, climate change, and environmental damage. These hardy grains grow with less water, survive tough weather, and provide better nutrition than rice and wheat. Adding millets to government food programs can fight malnutrition, while their cultivation supports small farmers and protects soil health. By encouraging millet production and consumption, India can move towards a healthier and more sustainable future.[6][7]

Climate-smart small millets (CSSMs) play a vital role in strengthening food security, enhancing nutrition, and supporting environmental sustainability. Crops like kodo, proso, foxtail, little, pearl, barnyard, and finger millet are highly resilient, requiring minimal water while providing greater nutritional benefits than conventional staples such as wheat and rice. Their rich nutrient profile makes them valuable in tackling malnutrition, obesity, and diabetes, while also benefiting farmers in drought-prone areas. As demand for millets rises in urban and global markets, incorporating them into mainstream agriculture and diets can contribute to better public health and sustainable food systems.[2]

2.4 Health Benefits of Millets and Multigrain

Several studies showed that multigrain consumption is associated with better glycemic control, enhanced nutrient intake, and improved cardiovascular health.[8]

Multigrain flour is widely recognized for its nutritional advantages, offering higher fiber, protein, and essential minerals. Research suggests that consuming multigrain-based products may lower the risk of obesity and chronic illnesses such as diabetes, heart disease, and certain cancers.[10]

A study by Yano (2019) highlighted that fortifying bread with soybean or oat flour significantly improved its protein quality and fiber content. Oat flour, in particular, was found to be rich in lysine, making it nutritionally superior to wheat protein. The addition of barley, flaxseed, and rye flour further enhanced dietary fiber, which plays a key role in reducing the risk of cardiovascular diseases, diabetes, and cancer.[11]

Similarly, a review by Hanna Kowalska et al. (2020) emphasized the nutritional value of multigrain bars, which can provide essential nutrients while eliminating refined sugar, unhealthy fats, and artificial additives. The study also underscored the importance of fiber in promoting health and improving the texture of food products.[12]

Another study by Sharma L. et al. examined the benefits of multigrain ladoos, indicating that multigrain foods support weight management, improve heart health, boost red blood cell production, and help regulate blood sugar levels [13][14].

2.5 Formulation of Multigrain Shakkarpare

To demonstrate the practical application of multigrains, a novel multigrain flour based traditional Indian multigrain snack, **Multigrain Shakkarpare**, was formulated. This formulation was designed to combine the nutritional benefits of various grains while catering to traditional Indian taste preferences.

2.5.1 Preparation Method:

Ingredients:

Amaranth, kodo millet, Finger millet, Sorghum, and Wheat flours for the base mix, along with Sugar, Cardamom powder, Ghee, refined oil, and salt, were procured from a local supermarket in Bhopal.

Preparation of Shakkarpara:

In a pan, combine 50 gm sugar with 1/3 cup of water and place it over medium heat.

Stir continuously until the sugar dissolves completely and the mixture starts to thicken. And check for single thread.

Turn off the heat and place the pan to thicken slightly.

Take 100 gm multigrain flour (atta) in a mixing bowl and add 50gm ghee and mix well**.**

Now add Water and knead the firm semi-solid dough. Cover and rest the dough for 30 minutes.

Further, roll it slightly thick like paratha. And Cut in a square shape, size of your choice.

Deep fry in medium hot oil with continuous stirring occasionally keeping the flame on medium.

Fry till the *shankarpara* turns golden and crisp. Keep it aside.

Add the fried *shakkarpare* into the prepared Chashni/Sugar syrup and stir well so that each piece is evenly coated.

Transfer the coated *shakkarpare* to a plate or bowl immediately to prevent sticking.

3 RESULTS

3.1 Historical Context and Agricultural Significance

The study highlights the long-standing role of millets in Indian agriculture, with their origins traced back to the Neolithic and late Harappan periods. Archaeological findings from regions such as Hallur, Hulas, and the Ganga Valley indicate that grains like finger millet, pearl millet, and sorghum were key components of early food systems. Their ability to thrive in varied climates with minimal water input made them well-suited for ancient subsistence farming. References in ancient Indian literature, including the *Yajurveda* and *Arthashastra*, reinforce their historic significance, predating the widespread cultivation of rice and wheat that gained momentum during the Green Revolution.

3.2 Current Status of Millet Production in India

Despite their decline in popularity in recent decades, the review suggests that millets are being rediscovered for their nutritional and environmental benefits. With current estimates showing millet cultivation across 14.6 million hectares and an annual yield of 12.5 million tonnes, India remains a leading producer. Pearl millet and sorghum dominate in both cultivation area and yield. Typically grown during the monsoon season, these crops support food and fodder availability in regions dependent on rainfall, contributing to climate-resilient agriculture.

3.3 Health Benefits of Millets and Multigrains

Findings from the literature also confirm that regular consumption of millets and multigrains can improve health outcomes. These grains are linked to better blood sugar control, increased fiber and protein intake, and a lower risk of non-communicable diseases such as diabetes and cardiovascular conditions. Fortifying multigrain flours with ingredients like soy, oats, barley, and flaxseed enhances their nutritional profile—particularly their protein content and fiber—which may help support weight management and metabolic health.

3.4 Nutritional Evaluation of prepared *Shakkarpare*

The nutritional analysis revealed that prepared multigrain S*hakkarpare* were analysed by using AOAC methods and had significantly great levels of Moisture, ash, protein, fat, crude fiber, calcium, and iron content (13.98, 1.78, 9.95, 44, 1.41,118.69 and 4.63 % respectively).

Table- 1 Nutritive value of Multigrain *Shakkarpara* (in percent)

Nutrients	Multigrain Shakkarpara
Moisture (%)	13.98
Ash (%)	1.78
Protein (%)	8.9
Fat (%)	22.5
CHO (%)	47.64
Crude fibre (%)	5.2
Calcium (%)	37.8
Iron (%)	5.1

3.5 Sensory Evaluation of prepared Shakkarpare

The sensory evaluation of the multigrain Shakkarpare were evaluated by 10 semi-trained panellist showed results showed in Table 2. The results showed that prepared multigrain shakkarpare was accepted and liked very much by all the panel members for its outstanding organoleptic qualities such as appearance, aroma,

texture, taste and overall acceptability.

Table- 2 Sensory Evaluation of the Multigrain Shakkarpare by 9-point hedonic scale.

Sample	Sensory Attributes				
	Appearance	Aroma	Texture	Taste/Flavor	Overall Acceptability
Multigrain Shakkarpara	7.3±0.94	7.9±0.31	7.3±1.25	7.7±0.67	8.1±0.73

(Values are mean ± SD)

4. CONCLUSION

This study critically reviewed the nutritional, environmental, and economic benefits of millets and multigrains, highlighting their potential in addressing current challenges related to health, climate change, and food security. The review revealed that while these grains offer significant advantages—such as high micronutrient content, climate resilience, and adaptability to low-input farming—they remain largely absent from mainstream diets due to factors like low consumer awareness, limited product innovation, and the dominance of refined cereals.

To contribute to bridging this gap, a traditional Indian sweet snack—*Shakkarpara*—was reformulated using a multigrain blend that included finger millet, pearl millet, sorghum, and wheat flour. The developed product was well-received during sensory evaluations, particularly for its taste, texture, and appearance, suggesting that millet-based snacks can successfully combine nutrition with cultural familiarity and consumer appeal.

The findings reinforce the need for nutrition professionals and food technologists to explore and develop more millet-based food products that are both nutritious and acceptable to modern consumers. Small changes in everyday food choices—such as replacing refined snacks with wholesome millet-based alternatives—can support a gradual shift toward healthier and more sustainable eating habits. Promoting such grains also creates opportunities for supporting small-scale farmers and improving agricultural sustainability through the cultivation of hardy, low-resource crops. In this way, the inclusion of millet-based snacks in regular diets not only improves nutrition but also contributes to building a resilient and environmentally conscious food system.

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