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Review

Biofortification of Millets: A Key Strategy to Combat Micronutrient Deficiencies in India

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Abstract

In the 2022 Global Hunger Index, India ranked 107th out of 121 countries, with the severity of hunger categorized as "serious." Approximately 16.3% of the population (about 224 million people) is undernourished, with a disproportionate impact on women and children. Malnutrition, stunting, wasting, and micronutrient deficiencies are widespread, contributing significantly to India's disease burden, particularly among children and pregnant women. To address these pressing nutritional challenges, the Government of India launched the POSHAN Abhiyaan (National Nutrition Mission), aiming to eradicate malnutrition and improve the nutritional outcomes of vulnerable populations. One promising solution to combat micronutrient deficiencies is biofortification, a process that enhances the nutritional content of crops through agricultural methods. This article explores the role of biofortification, with a particular focus on millets, in addressing India's micronutrient malnutrition crisis.

Keywords: Global Hunger Index, Malnutrition and biofortification.

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Introduction

Micronutrient deficiencies, often referred to as "hidden hunger," are a significant public health concern in India. Despite being a growing economy, India faces high levels of malnutrition, particularly due to the lack of essential micronutrients such as iron, zinc, and vitamin A. According to the Global Hunger Index, India ranks poorly in terms of hunger and malnutrition, with millions of its population suffering from deficiencies. Iron deficiency, for example, affects over 50% of pregnant women, 52% of non-pregnant women, and 74% of children aged 6–35 months. These deficiencies contribute to anemia, weakened immunity, poor cognitive development in children, and other health complications [1&2].

The burden of malnutrition is particularly high among vulnerable populations, including preschool children, school-aged children, adolescent girls, and pregnant and lactating women. In fact, over 40% of preschool children and 24% of school-aged children are anemic. These staggering statistics underscore the need for innovative solutions to address micronutrient deficiencies. One promising strategy is biofortification, which involves developing crop varieties with naturally higher levels of essential nutrients, offering a sustainable, cost-effective, and long-term solution to hidden hunger.

Biofortification: A Sustainable Solution to Micronutrient Deficiencies

Biofortification differs from traditional fortification and supplementation methods in that it enhances the nutrient content of crops through agricultural practices, rather than adding nutrients during food processing or providing supplements to individuals. This food-based approach to improving nutrition ensures that essential micronutrients are embedded in the staple foods that populations already consume, making it a more sustainable and scalable solution.

The potential benefits of biofortification are significant, especially in a country like India, where a large portion of the population relies on staple crops for their daily caloric intake. Biofortified crops are particularly beneficial for low-income populations, rural communities, and tribal areas, where access to diverse and nutrient-rich foods is limited. By incorporating biofortified crops into daily diets, these populations can improve their nutritional status without the need for expensive supplements or fortified processed foods.

Need for Biofortification in India

India's malnutrition crisis is rooted in widespread micronutrient deficiencies, especially among women and children. As mentioned, nearly 40% of preschool children, 24% of school-aged children, and 52% of pregnant women suffer from iron deficiency. Similarly, zinc deficiency affects 52% of children under the age of 5, while 70% of the population consumes less than half of the recommended daily intake (RDI) of essential micronutrients. These figures highlight the urgency of addressing micronutrient deficiencies at a large scale.

Biofortification presents a long-term and sustainable solution. By developing biofortified varieties of staple crops, India can provide its population with a regular and affordable source of essential nutrients. Furthermore, biofortified crops can be developed using traditional breeding methods, eliminating the need for costly and resource-intensive interventions. Once these crops are developed, there are no additional costs associated with obtaining higher nutritional value, making biofortification an affordable strategy for combating malnutrition.

Advantages of Biofortification

There are several advantages to biofortification as a strategy to combat micronutrient deficiencies in India:

1. **Cost-Effective:** Biofortified crops are a low-cost solution. Once the crops are developed, they can be cultivated without requiring additional inputs, making them a viable option for farmers in low-income and rural areas. The seeds of biofortified crops can also be saved and shared among farmers, further reducing the financial burden.
2. **Sustainability:** Biofortified crops offer a sustainable solution to micronutrient deficiencies, as they can be grown year after year. This ensures a continuous source of essential nutrients, especially for impoverished populations in rural and tribal areas.
3. **Wide Reach:** Biofortified crops can be widely grown in diverse agro-climatic regions of India, including marginal lands and arid areas where traditional crops may not thrive. This makes biofortification an inclusive approach that can benefit even the most vulnerable communities.
4. **Health Benefits:** Biofortified crops have the potential to improve the nutritional status of populations, particularly in areas where access to other sources of micronutrients is limited. In addition to providing essential micronutrients, biofortified crops can also have positive effects on managing health conditions such as anemia, diabetes, obesity, and hypertension.

5. **Adaptability:** Biofortified crops, particularly millets, are highly adaptable to diverse growing conditions. They are drought-resistant, fast-growing, and require fewer external inputs, making them ideal for regions prone to water scarcity and poor soil conditions.

Millets as Ideal Candidates for Biofortification

Millets, often referred to as "nutri-cereals," are ideal candidates for biofortification due to their inherent nutritional qualities. These small-grained cereals, including pearl millet, finger millet, sorghum, and other minor millets, are rich in protein, fiber, and essential micronutrients such as iron, zinc, calcium, and phosphorus. They are also naturally gluten-free, making them suitable for people with gluten intolerance.

Millets are known for their high levels of protein, especially in amino acids such as methionine, cysteine, and lysine. For example, pearl millet (bajra) contains the highest levels of fat and micronutrients among millets, while finger millet is particularly rich in calcium and potassium. Millets are also a valuable source of antioxidants, which contribute to their health benefits. These nutritional advantages make millets an excellent choice for biofortification efforts aimed at addressing micronutrient deficiencies.

Additionally, millets are widely accepted by rural and tribal populations, who have traditionally consumed them in various forms such as porridge, roti, and sargatti. Their acceptance and adaptability in local diets make them an effective vehicle for delivering essential nutrients to these communities.

Dhanshakti: The First Biofortified Pearl Millet Variety

One of the most significant achievements in the biofortification of millets is the development of the Dhanshakti variety of pearl millet. This biofortified variety was developed through the collaboration between HarvestPlus and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The development of Dhanshakti involved enhancing the iron and zinc content of the ICTP 8203 germplasm line, which led to the creation of a more nutrient-dense variety, ICTP 8203 Fe-10-2.

Dhanshakti was first released in Maharashtra in 2012 and nationally in 2014. The variety has shown promising results in addressing iron deficiency in populations that rely on pearl millet as a staple food. Research has demonstrated that consuming just 200 grams of Dhanshakti can provide 100% of the recommended daily iron intake for adult men and children and 60% of the recommended intake for non-pregnant, non-lactating women. Studies have also shown that incorporating iron-rich pearl millet into the diet can effectively improve iron levels in school-age children.

Pearl Millet HHB311

Dhanshakti (first biofortified variety of bajra)

The introduction of Dhanshakti has been well-received by both mothers and children, as the food products made from this biofortified millet are nutritious

and palatable. The success of Dhanshakti serves as a model for further biofortification efforts in other millet varieties and crops.

ICAR's Initiative to Develop Biofortified Varieties

The Indian Council of Agricultural Research (ICAR) has been at the forefront of biofortification research in India. In 2014, ICAR launched the Consortia Research Platform (CRP) on Biofortification to accelerate the development of biofortified crop varieties. The CRP focuses on staple crops such as rice, wheat, maize, sorghum, and pearl millet, aiming to improve their nutritional content through conventional breeding techniques.

As a result of this initiative, ICAR has developed around 17 biofortified varieties of rice, wheat, maize, and pearl millet. These varieties are already being adopted by farmers and are being incorporated into various government programs aimed at improving nutrition in India. Ongoing research continues to focus on enhancing the nutritional content of these crops, with an emphasis on improving the levels of iron, zinc, and other essential nutrients.

Table 1. Nutritional composition of millets (per 100 g)

Grain	Carbohydrates (g)	Protein (g)	Fat (g)	Energy (Kcal)	Dietary fibre (g)	Ca (mg)	P (mg)	Mg (mg)	Zn (mg)	Fe (mg)
Sorghum	67.7	9.97	1.73	334	10.22	28	274	133	2.96	3.95
Pearl Millet	61.8	10.96	5.43	348	11.49	27	289	124	2.76	6.42
Finger Millet	66.8	7.16	1.92	321	11.18	364	210	146	2.53	4.62
Kodo millet	66.2	8.92	2.55	332	6.39	15	101	122	1.65	2.34
Little millet	65.6	10.13	3.89	346	7.72	16	130	91	1.82	1.26
Proso millet	70.4	12.50	1.10	341	2.20	14	206	153	1.40	0.80
Foxtail millet	60.1	12.30	4.30	331	8	31	188	81	2.40	2.80
Barnyard millet	65.6	6.20	2.20	307	9.80	20	280	82	3.00	5.00

Source: Indian food composition tables, NIN–2017; *Crude fibre; # Based on nutritive value of Indian Foods, NIN–2007

Conclusion

Biofortification is a promising solution to the micronutrient deficiencies that plague millions of people in India. Millets, with their naturally high levels of essential nutrients, are ideal candidates for biofortification and can play a significant role in improving the nutritional status of rural and low-income populations. The development of biofortified varieties such as Dhan shakti demonstrates the potential of this approach to address the country's malnutrition crisis.

By incorporating biofortified millets into national nutrition programs like POSHAN Abhiyaan, the Public Distribution System (PDS), and Integrated Child Development Services (ICDS), India can improve the health and nutrition of its most vulnerable populations.

The widespread adoption of biofortified crops offers a cost-effective, sustainable, and long-term solution to the pressing issue of hidden hunger, ultimately contributing to a healthier, more nourished population.

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