

Biofortified millets

to alleviate micronutrient malnourishment

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In the 2022 Global Hunger Index, India ranks 107 out of the 121 countries and the severity of hunger is classified as 'serious'. The proportion of undernourished in the country is 16.3% (2019–21), which amounts to about 224 million people; majority of whom are women and children. Malnutrition and the resultant stunting, wasting, and nutritional deficiencies are prevalent among women and children. The bane of child and maternal malnutrition is responsible for 15% of India's total disease burden. The Government of India's POSHAN Abhiyaan or National Nutrition Mission is a flagship programme to improve nutritional outcomes for children, pregnant women and lactating mothers, and to ensure a malnutrition free India. In this regard, development of biofortified millet seems to be a convincing solution which has been discussed in this article.

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MOST widespread micronutrient deficiencies are that of iron (Fe), zinc (Zn) and vitamin A. Micronutrient malnutrition, also known as 'hidden hunger' affects more than one-half of the developing world's population, especially the women and pre-school children. It is also a food related public health concern in India where almost 40% pre-school children, 24% school going children and 40% female adolescents are anemic. More than 50% pregnant women are anemic.

More than half of anemia cases are due to iron deficiency alone. About 80% of pregnant women, 52% of non-pregnant women, and 74% of children in the 6–35 months age group suffer from iron deficiency. About 52% of children below 5 years of age are zinc deficient, while in adults it is 17–32%. The intake of micronutrients in daily diet is less than 50% RDA in over 70% of Indian population, which represents the severity of micronutrient deficiency in India.

Biofortification

Biofortification is the development of staple crop cultivars with higher levels of micronutrients. It differs from fortification (addition of an ingredient in food to increase the concentration of a particular element like iodized salt) or supplementation (addition of an element to the diet to make up for an insufficiency like vitamin capsules). In biofortification, micronutrient-dense grains are produced by the crop itself through

agricultural interventions. It is a food based approach to reduce the micronutrient malnutrition among the poor population.

Need

- It provides a long-term strategy of delivering more micronutrients, and is a powerful intervention tool to alleviate micronutrient malnourishment.
- Micronutrient enriched staple plant foods can significantly improve the amount of these nutrients consumed by the target populations.
- Biofortified crop varieties can be developed through conventional breeding programmes.
- Once biofortified varieties are developed, there is no additional expense involved in getting higher nutrition.

Advantages

- It targets low-income people and rural communities, and remote areas like tribal regions.
- Its recurrent costs are low, therefore biofortified varieties can be grown by farmers without extra cost and seeds can be shared.
- It is sustainable as its varieties will continue to be grown and consumed year after year.

Millets are nutri-cereals

- Millets are highly nutritious compared to fine cereals like rice.

- Millet grains contain high protein, fibre, micro and macronutrients and are gluten free.
- Millet protein has well balanced amino acid profile and good source of methionine, cystine and lysine.
- Pearl millet has the highest content of fat and micronutrients.
- Sorghum is a cheap source of energy, protein, iron and zinc next only to bajra.
- Finger millet is the richest source of calcium and potassium (400–420 mg/100 g).
- Other small millets are good source of phosphorous and iron.
- Phytochemicals in many of the millets act as antioxidants.

Millets as agents for biofortification

- The base level of micronutrients is high in millets providing advantage in further enrichment (Table 1).
- They possess added advantage of other nutritional benefits like rich in antioxidants.
- Millets are readily acceptable to poor people requiring nutritional intervention.
- They are mostly grown in marginal lands and tribal regions where poor people live.
- They are consumed in the form of various traditional foods like porridge, roti, sargatti, etc.
- Millet is drought resistant crop having short-duration and less incidence of diseases and pests.
- It requires less external inputs and hence, is most suitable for arid and semi-arid regions.
- It is helpful in the treatment of diabetes, obesity, blood pressure, heart diseases, cancer, etc.
- Millets act as immune boosters due to presence of vitamins and essential minerals.
- Different value-added products can be prepared from millets to target urban population suffering from lifestyle diseases.

Dhanshakti-first biofortified pearl millet variety

Pearl millet has the highest content of iron in its grains. Large variability for both iron and zinc has been reported in pearl millet varieties and hybrids. In order to enhance the content of iron and zinc further and with an aim to



Dhanshakti (first biofortified variety of pearl millet)

Pearl millet HHB 311

reduce the micronutrient deficiency among the people consuming pearl millet as staple food, HarvestPlus in association with ICRISAT started working on pearl millet biofortification in the early 2000s.

By exploiting variability available within population of a germplasm line ICTP 8203 for iron content, an improved version, ICTP 8203 Fe-10-2 was developed. It was released as 'Dhanshakti' in collaboration with MPKV, Rahuri first in 2012 in Maharashtra and later across India in 2014. The variety is adapted to Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Madhya Pradesh, Rajasthan, Uttar Pradesh, Haryana and Punjab.

Three independent studies showed that consumption of 200 g of 'Dhanshakti' can meet 100% of recommended daily allowance (RDA) of iron in adult men and children in India and 60% of the RDA in non-pregnant and non-lactating women. Studies also indicated that feeding iron rich pearl millet is an efficacious approach to improve iron status in school-age children. The food products made out of Dhanshakti were readily accepted by both mothers and children.

ICAR's initiative to develop biofortified varieties

In order to accelerate the development of biofortified varieties and enhance the nutritional value of commonly consumed staples, ICAR launched a Consortia Research

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

Grain	Carbo-hydrates (g)	Protein (g)	Fat (g)	Energy (KCal)	Dietary fibre (g)	Ca (mg)	P (mg)	Mg (mg)	Zn (mg)	Fe (mg)
Sorghum	67.7	09.97	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	07.16	1.92	321	11.18	364	210	146	2.53	4.62
Kodo millet	66.2	08.92	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	8.00*	31	188	81	2.40	2.80
Barnyard millet [#]	65.6	06.20	2.20	307	9.80*	20	280	82	3.00	5.00
Wheat	64.7	10.59	1.47	322	11.23	39	315	125	2.85	3.97
Rice	78.2	07.94	0.52	356	2.81	7	96	19	1.21	0.65

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

Platform (CRP) on Biofortification addressing rice, wheat, maize, sorghum, pearl millet and small millets since 2014. The programme has resulted in development of about 17 biofortified varieties of rice, wheat, maize and pearl millet. Further research efforts in all the crops are still ongoing.

Biofortified pearl millet cultivars

The All India Coordinated Research Project on Pearl Millet (AICRP-Pearl Millet) is working on development of biofortified pearl millet cultivars. Separate biofortification trials were conducted to evaluate pearl millet varieties and hybrids with high iron and zinc content. A few biofortified cultivars with higher iron and zinc content along with high grain yield were released for farmers. Since 2018, AICRP-Pearl Millet has set a minimum 42 mg/kg of iron and 32 mg/kg of zinc for promoting entries in the trials and cultivar release. Presently, many high yielding cultivars having moderate to high iron and zinc content are available to the farmers for cultivation (Table 2).



Finger millet CFMV 1 (Indravathi)



Finger millet CFMV 2 (Gira)

Sorghum

Sorghum is the second cheapest source of energy and micronutrients after pearl millet. Sorghum consumption, especially by low and middle-income rural consumers, is high in the major production regions of inland central and eastern regions of Maharashtra and inland northern region of Karnataka. In terms of nutrient intake, sorghum accounts for about 35% of the

Table 2. Latest biofortified hybrids/varieties of pearl millet

Hybrid/Variety	GY (kg/ha)	Duration (days)	Year	Fe (mg/kg)	Zn (mg/kg)	Developer	Area of adoption
Dhanshakti (ICTP 8203 Fe 10-2)	2199	76	2014	81	43	MPKV, Dhule	Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Rajasthan, Haryana, Madhya Pradesh, Gujarat, Uttar Pradesh, Punjab
Mahabeej 1005 (MH 1852)	2994	81	2017	62	37	MSSCL, Akola	Maharashtra
AHB 1200 Fe (MH 2072)	3170	78	2018	77	39	NARP, Aurangabad	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra, Telangana, Andhra Pradesh, Tamil Nadu
HHB 299 (MH 2076)	3274	81	2018	73	41	CCSHAU, Hisar	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra, Tamil Nadu
NBH 4903 (MH 2035)	4444	85	2018	70	63	Nuziveedu Seeds, Hyderabad	Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu
AHB 1269 Fe (MH 2185)	3168	82	2019	91	43	NARP, Aurangabad	Rajasthan, Haryana, Gujarat, Punjab, Delhi, Maharashtra, Tamil Nadu,
RHB 233 (MH 2173)	3157	80	2019	83	46	SKNAU, Jobner	Rajasthan, Haryana, Gujarat, Madhya Pradesh, Punjab, Delhi, Maharashtra, Tamil Nadu
RHB 234 (MH 2174)	3169	81	2019	84	41	SKNAU, Jobner	Rajasthan, Haryana, Gujarat, Madhya Pradesh, Punjab, Delhi, Maharashtra, Tamil Nadu
Phule Mahasakthi	2581	83	2019	85	37	MPKV, Dhule	Maharashtra
HHB 311 (MH 2179)	3173	80	2020	83	39	CCSHAU, Hisar	Rajasthan, Haryana, Gujarat, Madhya Pradesh, Punjab, Delhi, Maharashtra, Tamil Nadu
Moti Shakti (GHB 1225)	3023	-	2020	76	46	JAU, Jamnagar	Gujarat
GHB 1129 (Jam Shakti)	2957	80	2021	72	43	JAU, Jamnagar	Gujarat
VPMH 7	2352	84	2021	67	52	UAS, Dharwad	Karnataka
GHB 1231 (Sawaj Shakti)	2760	-	2021	81	41	JAU, Jamnagar	Gujarat
HHB 67 Imp 2	2000	-	2021	55	40	CCSHAU, Hisar	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Delhi

Table 3. Biofortified varieties of small millets

Crop	Variety	GY (kg/ha)	Ca (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Developer	Area of adoption
Finger millet	CFMV 1 (Indravathi)	3110	4280	58	44	ARS, Vizianagaram	Andhra Pradesh, Karnataka, Tamil Nadu, Puducherry, Odisha
Finger millet	CFMV 1 (Gira)	2950	4740	39	25	HMRS, Waghai	Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra, Odisha
Little millet	CLMV 1 (Jaicar Sama-1)	1580	-	59	35	IIMR, Hyderabad	Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu, Puducherry

total intake of calories, protein, iron and zinc in these dominant production/consumption regions. Hence, biofortification of sorghum is a promising strategy to alleviate iron and zinc deficiency in these rural areas of dryland. Wide variability for grain iron (12–68 mg/kg) and zinc (11–44 mg/kg) has been observed among the cultivars and germplasm lines. Several of the released and popular sorghum cultivars possess moderate amounts of grain iron and zinc. Regular consumption of these would elevate the micronutrient status among the sorghum consuming population. Currently, efforts are on to developing biofortified sorghum varieties combining high yield and micronutrients.



Little millet CLMV 1 (Jaicar Sama-1)

Small millets

Small millets are highly nutritious and superior to rice for mineral content. The protein content ranges from 7–12% and fat content from 1–5%. Iron and zinc are relatively in higher concentrations in small millets compared to other major cereal crops. Varietal variations

exist for both iron and zinc content. Finger millet is a very rich source of calcium (Ca), but grains also contain anti-nutritional factors like tannin (up to 3%) in larger quantities with strong negative correlations with iron and zinc. Processing techniques like soaking, roasting, boiling, germination, fermentation and malting tend to reduce tannin content and enhance the availability of micronutrients. Research efforts are going on to develop small millet varieties with high iron and zinc content. On the occasion of World Food day 2020, the Prime Minister, Shri Narendra Modi dedicated two finger millet varieties, CFMV 1 and CFMV 2 rich in calcium, iron and zinc, and one small millet variety CLMV 1 rich in iron and zinc to the nation (Table 3).

SUMMARY

Millet grains contain higher protein, fibre, calcium and mineral nutrients, and can ensure better nutrition to the poor people. Biofortification in millets is a feasible strategy to alleviate the micronutrient malnutrition among the rural poor. Several biofortified cultivars have been released in pearl millet for commercial cultivation and are being adopted by the farmers. The availability of high variability for grain micronutrient contents in sorghum and small millets holds promise to develop superior cultivars with enhanced nutritional quality. Wide adoption and consumption of such biofortified millets by micronutrient malnourished poor people will enhance the nutritional status and health condition of rural as well as urban population. Integration of biofortified cultivars of millets in Government programmes like POSHAN Abhiyaan, PDS and ICDS can make the nutritional interventions more practical and cost-effective to deliver the micronutrients to the target communities.

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Protect environment.**

