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Biofortified Millets: A Panacea for Hidden Hunger

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Introduction:

Under nutrition due to an insufficient intake of organic macronutrients (carbohydrates, proteins, fats, etc.) leads to chronic hunger, which contributes to conditions like underweight, wasting, and stunting. There has been much discussion about this in various global forums as a food security issue. Unlike macronutrients, which must be consumed in large quantities for proper growth and development, micronutrients (Table.1) are essential in trace amounts, but play crucial physiological roles. Micronutrient deficiencies are known as hidden hunger, as they do not manifest themselves as obvious hunger symptoms, like macronutrient deficiencies. Some micronutrient deficiencies, are however, more widespread, and their adverse health effects are more severe.

For instance, it has been reported that iron (Fe) and zinc (Zn) deficiencies are the most common, affecting more than two billion people globally, primarily in low- and middle-income countries. Indians, even though they have experienced impressive economic growth, are disproportionately deficient in these two micronutrients, especially in rural areas and urban slums. It is estimated that iron deficiency-induced anemia affects 80% of pregnant women, 52% of non-pregnant women, and 74% of children between the ages of 6-35 months in India. Zinc deficiency affects 52% of children under the age of 5. The Fe deficiency can impair cognitive function, lower work capacity, reduce immunity to infections, and cause pregnancy complications (e.g., low birth weight and poor learning capacity). Severe anemia caused by iron deficiency is one of the leading causes of maternal and child mortality. A zinc deficiency in children leads to diarrhea, pneumonia, mortality, and stunting. To address micronutrient deficiencies, pharmaceutical approaches of supplementation, industrial approaches of food fortification, and agricultural approaches such as dietary diversification

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and biofortification have been advocated. The concept of crop biofortification, which refers to breeding crops with higher levels of micronutrients, is becoming increasingly popular due to its cost-effectiveness and sustainability.

Macronutrients		
Nutrient		**RDA or AI (adults > 19 years)**
Carbohydrates		130 g (gram)
Proteins		45-55 g
Fats		10-20 g
Micronutrients		
Nutrient		**RDA or AI (adults > 19 years)**
Water-soluble vitamins	Vitamin B1 (Thiamine)	1.1-1.2 mg (milligram)
	Vitamin B2 (Riboflavin)	1.1–1.3 mg
	Vitamin B3 (Niacin)	14–16 mg
	Vitamin B5 (Pantothenic acid)	5 mg
	Vitamin B6 (Pyridoxine)	1.3 mg
	Vitamin B7 (Biotin)	30 mcg (microgram)
	Vitamin B9 (Folate)	400 mcg
	Vitamin B12 (Cobalamin)	2.4 mcg
	Vitamin C (Ascorbic acid)	75–90 mg
Fat-soluble vitamins	Vitamin A	700-900 mcg
	Vitamin D	600-800 IU
	Vitamin E	15 mg
	Vitamin K	90-120 mcg
Macro Minerals	Calcium	2,000-2,500 mg
	Phosphorus	700 mg
	Magnesium	310-420 mg
	Sodium	2,300 mg
	Chloride	1,800-2,300 mg
	Potassium	4,700 mg
	Sulphur	None established

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Trace Minerals	Iron	8–18 mg
	Manganese	1.8–2.3 mg
	Copper	900 mcg
	Zinc	8–11 mg
	Iodine	150 mcg
	Fluoride	3–4 mg
	Selenium	55 mcg
RDA (Recommended Dietary Allowance) **AI** (Adequate Intakes)		

Table 1: Classification of various macro and micronutrients and their recommended daily allowances.

Why millets?

Micronutrient malnutrition predisposes humans to different forms of diseases, which can be alleviated by biofortifying staple food crops. Rice, wheat, maize and barley are four of the major staple crops that meet food security; however, biofortified crops such as millets are widely considered nutritionally important.

Nearly 80% of millet grains are used for food, whereas 20% are used for feed and industry. Millet grains are high in protein, vitamins, and minerals. For newborns, lactating mothers, convalescents, and the elderly, millets are an ideal source of nutrition. Granules dissipate sugar slowly into the circulation, which is why they are also considered as "sans gluten". The high protein and fiber content of millets have driven a high demand for them as dietary nourishment for individuals with cardiovascular illnesses and diabetes. The phenolic acids and flavonoids found in millets scavenge free radicals from oxidative stress, therefore lowering blood sugar levels. In pearl millet, iron (Fe) and zinc (Zn) are in the range of 5-11.2 and 3-7.1g/100g, respectively, with considerable amounts of bioactive substances such as phenols, carotenoids, and phenolic acids. Finger millet has abundant polyphenols, minerals such as calcium, magnesium, and potassium and elevated levels of amino acids such as lysine and methionine, tryptophan. A barnyard millet has a high rough fiber content (13.6%) and a high level of iron (186 mg/kg dry matter), while a proso millet has the highest protein content (12.5%). A key ingredient in barnyard millet grains is gamma-aminobutyric acid (GABA), which acts as a cell-reinforcing biochemical and can lower blood lipids. Interestingly, little millet and kodo millet both contain high levels of dietary fiber. In addition, little millet contains high levels of magnesium (1.1 g/Kg dry matter).

Harvest Plus group realized the importance of millet biofortification and released conventionally bredhigh iron pearl millet in India to tackle iron deficiency. A variety of biofortified millets and sorghum are being developed to combat malnutrition in developing countries using conventional breeding techniques and recombinant DNA technology. This increased nutritional content includes: a higher amylopectin content, a higher lysine content, increased protein digestibility, high provitamin A content, high iron and zinc content, and reduced phytates that improve mineral bioavailability. Several of these biofortified cereals have excellent agronomic properties and valuable commercial end-use attributes, which will facilitate farmers' adoption.

Biofortification

The goal of biofortification is to make essential limiting elements, particularly micronutrients, more concentrated and bioavailable in staple food crops. There is strong evidence that the intake of these grains with added macro- and micronutrients helps reduce malnutrition in underdeveloped nations.German studies found that Quality Protein Maize (improve high lysine maize) consumption in place of regular maize significantly boosted the rate of growth in weight and height of new-borns and young children with mild to moderate undernutrition. Similar to Golden Rice, rice that has been biofortified with provitamin A could reduce the illness burden associated with vitamin A deficiency in India by more than half, according to excellent estimated data.There are three different methods of biofortification: agronomic (raising micronutrients by soil amendments or foliar spray), conventional breeding (which includes induced mutagenesis), and recombinant DNA technology (genetic engineering, GM). The latter two procedures entail genetic modification of the grains.These technologies only require an upfront investment, and hence from a practical standpoint their implementation reduces recurrent costs tofarmers.

Pearl Millet

Pearl millet (also known as bajra) is a major source of dietary energy and nutritional security. It has high levels of protein with better amino acid balance than other major cereals such as rice, wheat and maize. It also hashigh levels of fat content, dietary fibre, and several minerals, including iron and zinc.

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In pearl millet, there are two types of cultivars grown by farmers. These are open-pollinated varieties and hybrids, though the latter dominate the scene in India on account of their grain yield superiority and greater uniformity for plant and grain traits.

Various multi-location trialsof many open pollinated varieties and hybrids jointly conducted by ICRISAT and All India Coordinated Pearl Millet Improvement Project,showed iron content varying from 42 to 67 mg/kg in varieties and from 31to 61 mg/kgin hybrids. The zinc content varied from 37 to 52 mg/kgin varieties and from 32 to 52 mg/kgin hybrids. Clearly, all of these pearl millet cultivars had much higher iron content than the best ricevarieties(less than 20 mg/kg). Many, but not all, had markedly higher iron content than the best wheat varieties (less than 45 mg/kg). Also, many had markedly higher zinc content than the best rice varieties (less than 30mg/kg), but only few had higher zinc content than the best wheat varieties (less than 45 mg/kg).

Pearl Millet			**Fe (ppm)**	**Zn (ppm)**
Varieties:	*Dhanshakti*		71	40
	ICMV 221Fe11-2		81	51
Hybrids:	ICMH 1201		75	>40
	ICMH 1301		77	>40
	HHB 229 (developed by CCSHAU)		73	41
	HHB 311 (developed by CCSHAU)		83	41
Foxtail Millet				
	Suryanadi (SiA 3088)		129	-
Little Millet				
Pure Line Variety	CLMV 1		59	35
	OLM-203		51	-
Finger Millet		**Calcium (mg/g)**		
Pure Line Varieties	VR 929 (Vegavathi)	-	131.8	-
	CFMV 1 (Indravati)	428	58	44
	CFMV 2	454	39	25
	GPU-28	-	69.9	-

Table 2: Some biofortified varieties/hybrids of major millets with their micronutrient contents

Conclusion

Global health is thought to be significantly impacted by micronutrient deficiencies. In this regard, millets are particularly nutritious crops that can be widely used to combat nutritional insufficiency in Asia and Africa. Biofortification is an extremely sustainable and cost-effective method of alleviating micronutrients inadequacy. Millets are in favour of good acceptance to fulfil the demands of biofortification strategies because they have desirable grain qualities and high levels of essential amino acids, minerals, and nutrients. Millets are often particularly rich in phenolic phytochemicals, according to studies, which may have significant health-promoting properties. Because of this, including these little grains in everyone's diet will increase dietary diversity among people and preserve the biodiversity of food plants. Additionally, biofortified millets offer a great scope in creating low-cost, protein-rich functional food items for improved nutritional security.