Biofortification: A promising solution for combating micronutrient deficiencies and enhancing human health

Abstract

Biofortification is a promising strategy aimed at addressing widespread micronutrient deficiencies and improving human health. Micronutrient deficiencies, such as vitamin A, iron, and zinc deficiencies, pose significant public health challenges, particularly in developing countries where access to diverse and nutritious diets is limited. Biofortification involves the breeding or genetic modification of staple food crops to increase their micronutrient content, thereby providing a sustainable and cost-effective solution to tackle these deficiencies.

Keywords: bioavailability, malnutrition, micro-nutrients, undernutrition

Introduction

In India, the second most populous country in the world, cereal crops including rice, wheat, and bajra are a major source of the country's daily energy needs and nutritional needs. There isn't a single crop among these that can provide all the necessary nutrients in a balanced manner. Malnutrition has thus become one of the country's most difficult problems. Malnutrition is brought on by the eating of an imbalanced diet that is low in nutritious value. Poor health and general growth result from a lack of nutritional supplements such proteins, vital amino acids, vitamins, and minerals. According to the Food and Agriculture Organisation (FAO) of the United Nations, "hunger" is defined as a person's regular intake of inadequate calories to meet their minimum dietary energy needs in order to live a healthy and productive life. According to a National Health Survey-2017 study, about 19 crore individuals in the nation are forced to go to bed every night on an empty stomach. 35.5% of children under the age of five in India had stunting, 19.3% had wasting, and 32.1% had an underweight condition, per the National Family Health Survey-5 (NFHS-5) report. A healthy mind is the most crucial tool for the advancement of nations, and a healthy body follows from a healthy mind. Given the significance of the issue, the government has launched numerous programmes to address the problems. Numerous initiatives in this regard, including dietary diversity, food fortification, and medical

supplements, have been largely effective. But in order to completely eradicate the malnutrition issue, concepts that are rapid, affordable, and sustainable must be developed. Biofortification of crop varieties is considered as the most viable approach which has work on same principle and cover the broad peoples in a effective and sustainable ways. Recently many newly biofortified crop varieties developed by various research institutes which can serve as an important source for livelihood and nutritional security in the country**.**

Hunger Index: Global hunger index (GHI) which is decided based on four indicators i.e. Undernourishment, Child Wasting, Child Stunting, and Child Mortality.

The countries most impacted by world hunger and malnutrition, according to the Global Hunger Index Report 2021, are Somalia, Yemen, the Central African Republic, Chad, the Democratic Republic of the Congo, Madagascar, and Liberia. According to the GHI 2021 ranking, Somalia has the worst hunger issue.It has a GHI score of 50.8, which is quite frightening. India, which has a score of 27.5 and is ranked 101st out of 116 countries, is likewise severely suffering from the hunger crisis.

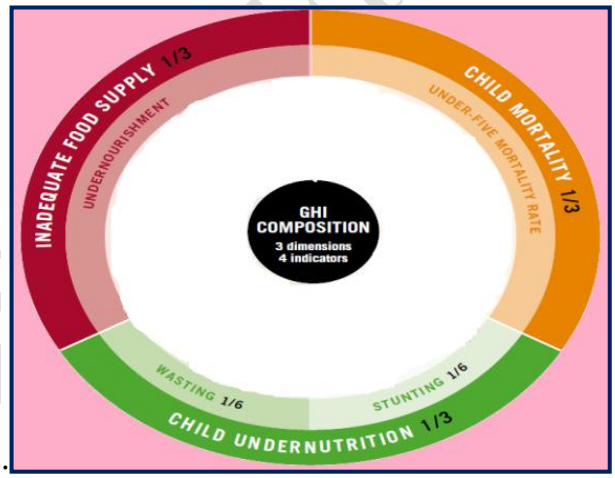
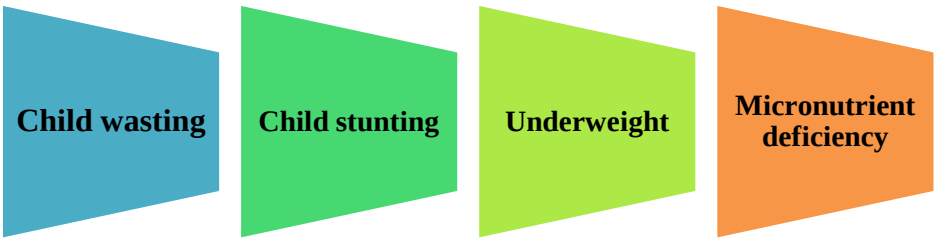


Fig. 1GHI compositions and indicators

Malnutrition: Inadequate or excessive nutritional intake, an uneven intake of essential nutrients, and inefficient nutrient utilisation are characteristics of malnutrition. Malnutrition includes undernutrition, overweight, and obesity, which give rise to non-communicable diseases linked to an unbalanced diet. In India, 36 percent of young children have stunted growth (too short for their age), 32 percent underweight, 19 percent

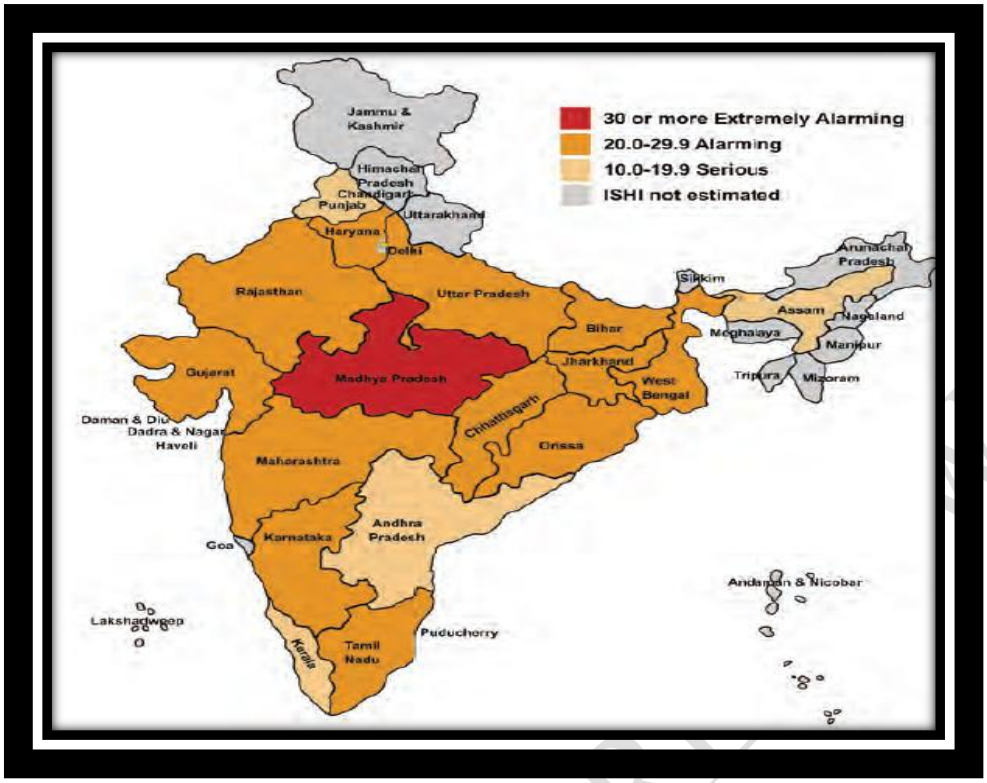
wasted (too thin for their height), 3 percent are overweight under the age of five years which are an indication of severe malnutrition.

Fig .2 The 4 broad forms of malnutrition:



Major causes of hunger and malanutrition severity in India

1. Economic inequality and poor purchasing power in the country
2. Continous monoculture agricultural practice that has led to the degradation of production resources resulted food-derived through them are poor quality.
3. Poor diversification of daily diet and long time using the cereals based diet specially during critical stages of the development.
4. Climate change is one of the major reason which has increasing food insecurity through higher temperatures, changing precipitation patterns, and more frequent extreme weather events.
5. Phycical attraction has given more wegtage by the young generation during early days of the life.
6. Occurance of severe stress, pest and disease which degrade of the quality of the crop produces.
7. Unbalance fertilization of the crop has lead to poor quality produces.
8. Social inequality: Girls children are more likely to be malnourished than boy children in rural areas.
9. Poor sanitation
10. Pandemic diseases in crops and humans.
11. Lower health awareness



Map 1: Indian state's malnutrition severity reports as per NFHS-5

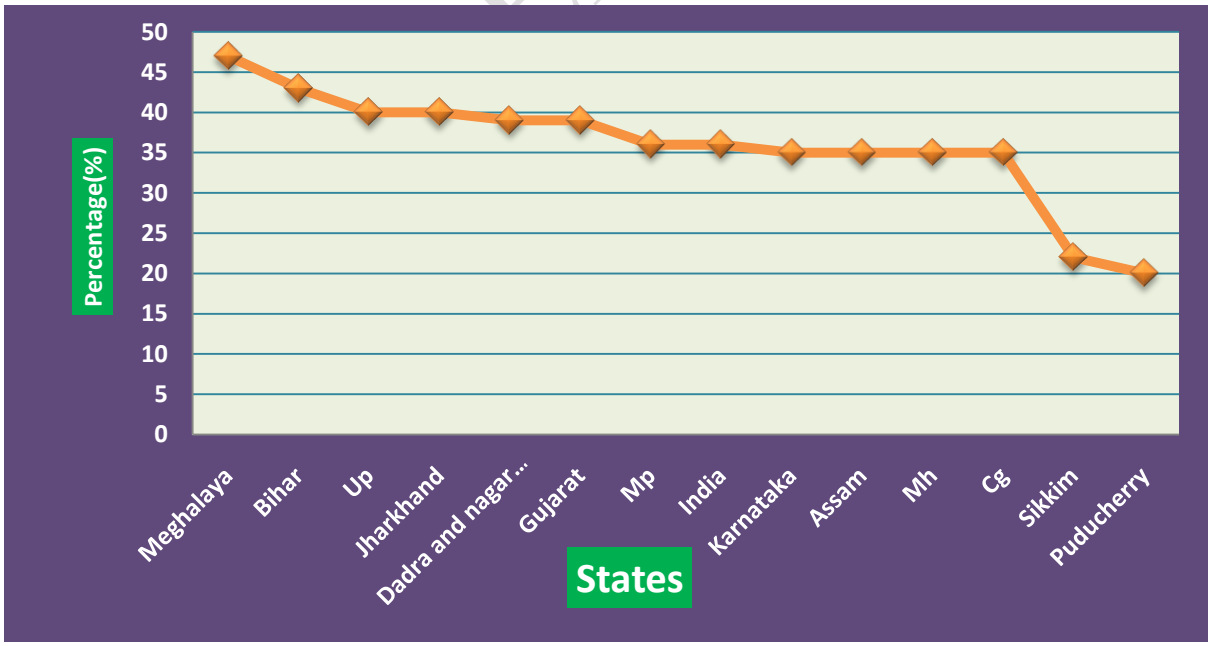


Fig .3 Statewise stunting percentage of children aged (0-59) months

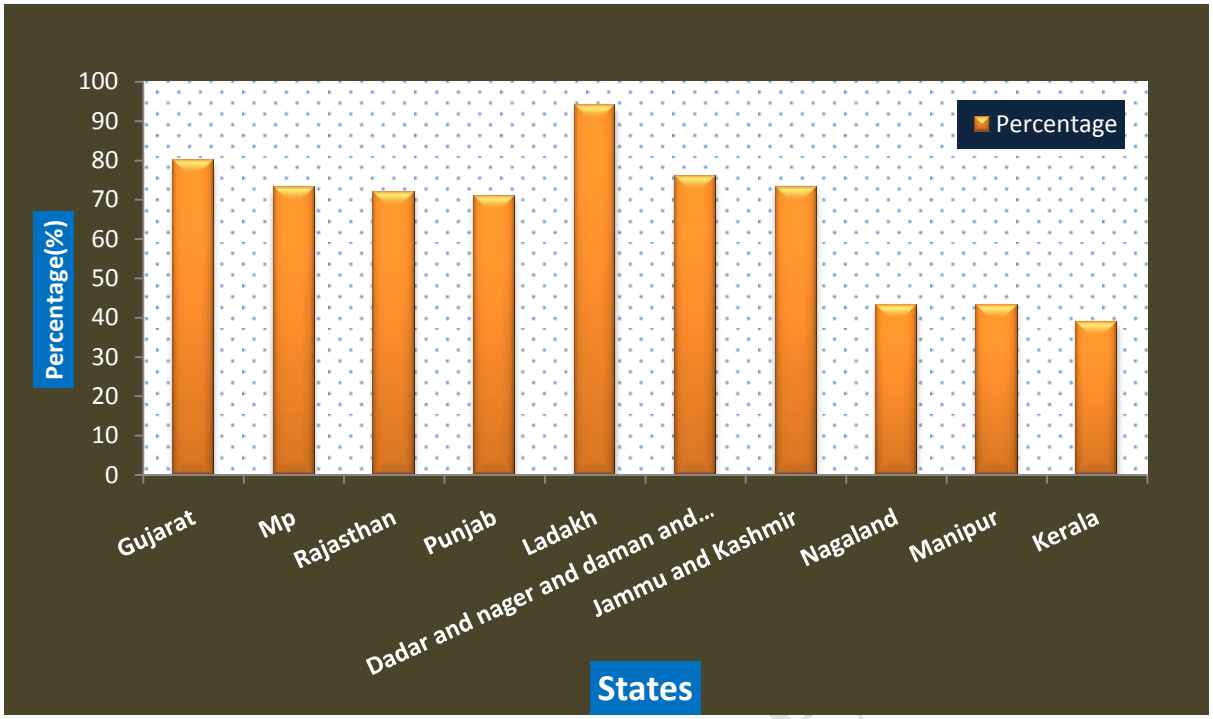


Fig. 4 Statewise prevalence of anemia among children aged 6-59 months

Approaches of solving the malnutrition problem

1. By improving the purchasing power and minimizing social inequality:- This can be achieved by increasing employment opportunities in rural as well as urban areas during whole the years.

2. Developing basic health infrastructure and awareness programmes on mass level; major government schemes in India to alleviate malnutrition:

I. **Eat Right India Movement**: The Food Safety and Standards Authority of India (FSSAI) started it to make sure that all Indians have access to nutritious, sustainable food.

II. **POSHAN Abhiyan**: The National Nutrition Mission (NNM), also known as Poshan Abhiyaan, was introduced in 2018 by the Ministry of Women and Child Development. This is a flagship programme to enhance adolescent, child, pregnant, and lactation nutritional outcomes.

III. **Pradhan Mantri Matru Vandana Yojana (PMMVY)**: The primary goals of PMMVY, formerly known as the Indira Gandhi Matritva Sahyog Yojana, are to improve the health of expectant and nursing mothers and lessen the effects of undernutrition through financial incentives. Under the programme, pregnant

women and lactating mothers would get a monetary incentive of 5000 (paid in three installments) immediately into their bank or post office accounts. The Ministry of Women and Child Development is responsible for carrying out the programme.

IV. **Mission Indradhanush**: The major goal of Mission Indradhanush is to guarantee that children and expectant mothers receive the full range of available immunisations nationwide. Free immunisation against 12 vaccine-preventable diseases (VPD) for children under 2 years old and expectant women.

V. **Integrated Child Development Services (ICDS) Scheme**: With the implementation of six services for babies and young children, pregnant women, and nursing mothers (preschool non-formal education, supplemental nutrition, nutrition & immunisation, health education, and referral services and health check-up), this took effect in October 1975.

3. By increasing food production: Although India is self dependent in food production, even though a large section of the country i.e. rural poor are devoid of food due to financial problems. Although government has commited to ensure the food security through flafship programme is National Food Security Act (NFSA), 2013. Under the scheme government has provided the subsidized foodgrains in very affordable prices. It allows the authority to provide subsidised food grains to up to 75% of rural and 50% of urban population respectively through targeted PDS.

4. Diversification of the existimg food crops with millets crops: Continouslly adoption of Rice-wheat based food style have created the deficiency of certain essential mineral which are deficient in crops. Longterm selection of limited crops based food style has increasing the problem of malnutrition in very broad level. Climate change is also an another aspect which significantly influenced the quality and productivity of the existing cultivated food crops. In general conventional food crops (Rice &wheat) are more sensitive than other coarse cereal and minor millets. Hence. Its urgent need of time to diversify the growing crops with newly developed climate hardy and nutritive crops and varieties. Millets are also known as nutri cereals because of their high nutritional value and its inclusion in existing cropping system will help in overcoming the malnutrition problems. Consuming food containing nutraceuticals provides both health benefits and lowering risks from chronic illnesses like cardiovascular diseases, some malignancies, and

obesity. They are rich in antioxidants which have power to counteract the effects of free radicals, which are potentially detrimental by-products of a number of physiological processes and are linked to the ageing of cells and tissues.

Table 1: Comparative nutritional composition of millets crops

Crops	Protein (%)	Crude fiber (%)	Carbohydrate (%)	Energy (kcal)	Thiamine (µg/100gm)	Riboflavin (µg/100gm)
Pearl millet	11.8	2.3	67.0	363	0.38	0.21
Foxtail millet	12.3	8.0	60.9	351	0.42	0.19
Little millet	7.7	7.6	67.0	329	0.41	0.28
Kodo millet	8.3	9.0	65.9	353	0.33	0.10
Finger millet	7.3	3.6	72.0	336	0.38	0.21
Proso millet	12.5	7.2	70.4	364	0.59	0.11
Barnyard millet	6.2	9.8	65.5	300	0.30	0.09
Sorghum	10.4	2.0	62.5	329	0.38	0.15

Source: Mehanathan *et al*., 2016

Table 2: Comparative trace elements composition in millets:

Grain	P	Mg	Ca	Fe	Zn	Cu	Mn
	----------ppm----------						
Pearl millet	379	137	46	8.0	3.1	1.06	1.15
Foxtail millet	422	81	38	5.3	2.9	1.60	0.85
Little millet	251	133	12	13.9	3.5	1.60	1.03
Kodo millet	215	166	31	3.6	1.5	5.80	2.90
Finger millet	320	137	398	3.9	2.3	0.47	5.49
Proso millet	281	117	23	4.0	2.4	5.80	1.20

Barnyard millet	340	82	21	9.2	2.6	1.30	1.33

Source: Mehanathan *et al*., 2016

5. Through crop bio-fortification: It is the process of enhancing the nutritional value of food grains using agronomy, conventional breeding, and/or biotechnology methods in order to increase the bioavailability of quality factors to the target population or decreasing the anti-nutritional factors. Until now, the main emphasis on ensuring food security in our country has been on boosting crop yield and productivity, avoiding the areas of quality products and human health. This strategy has caused food grains' vitamin deficiencies and other quality issues to rapidly increase, worsening consumer malnutrition. The production of sufficient amounts of nutrient-rich food crops is now our top priority. Traditional methods of quality improvement are time-consuming, resource-intensive, and less effective. Therefore, biofortification of many crop kinds offers a long-term and sustainable alternative for providing people with wholesome nourishment.

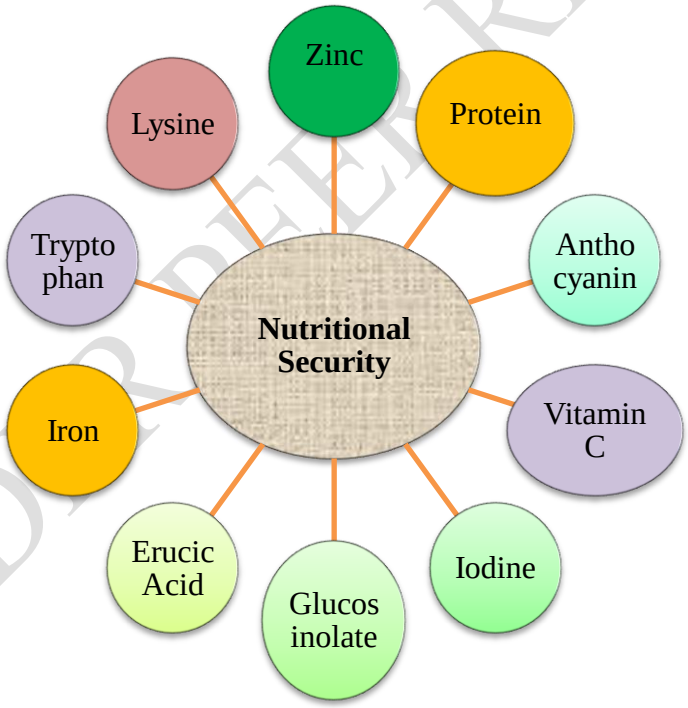


Fig. 5 Nutritonal Security with Nutritional factor

Table. 3 Comparative change in baseline level of nutrients in biofortified crops

Crop	**Nutritional factor**	**Baseline levels**	**Nutritional level after biofortification**
Rice	Zinc	12.0- 16.0 ppm	>20.0 ppm

	Protein	7.0- 8.0%	>10.0%
Wheat	Iron	28.0- 32.0 ppm	>38.0 ppm
	Zinc	30.0- 32.0 ppm	>40.0 ppm
	Protein	8- 10%	>12.0%
Maize	Lysine	1.5- 2.0%	>2.5%
	Tryptophan	0.3- 0.4%	>0.6%
	Provitamin A	1- 2 ppm	>8.0 ppm
Pearl millet	Zinc	30.0- 35.0 ppm	>40.0 ppm
	Iron	45.0- 50.0 ppm	>70.0 ppm
Mustard	Glucosinolates	>120.0 ppm	<30.0 ppm
	Erucic acid	>40%	<2.0%

Source: Yadava *et al.*, 2018

Table 4: Some biofortified varieties:

Rice	CR Dhan 310 (protein-rich), DRR Dhan 45, CR dhan 315 (zinc-rich)
Wheat	WB 02, HPBW 01 (zinc & iron rich), HD 3298, DBW 303 and DDW 48 rich in protein and iron
Maize	Pusa Vivek QPM 9 Improved (provitamin-A, lysine & tryptophan rich hybrid), Pusa HQPM 5 Improved (provitamin-A, lysine & tryptophan rich hybrid), Pusa HM 4 Improved, Pusa HM 8 Improved, Pusa HM 9 Improved (lysine & tryptophan rich hybrid)
Lentil	PusaAgeti Masoor (iron rich)
Finger millet	CFMV 1 and CFMV 2 rich in iron, zinc and calcium
Small millet	CCLMV1 rich in iron and zinc

Source: ICAR

Conclusion:

It is very much clear that hunger and malnutrition are the severe constraints for sustainable development of the nationa. Without maintain the health of their citizen no one can achive the goal of sustainable development because Health is the biggest wealth for a living being in entire life. To overcomethese problem, strategies such as diversification of food style,

reducing poverty, inclusion of nutri-cereals (millets), climate resilient food production, developing the quality rich variety and bio fortification of food crops are the prime need toeradication of hunger and malnutrition in a sustainable way.

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