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Biofortification in Millets for Reducing Malnutrition

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Introduction

Human health is adversely affected by micronutrient malnutrition, sometimes known as hidden hunger or inadequate vitamin and mineral consumption. Over two billion people worldwide suffer from hidden hunger, with South Asia and the African continent having the greatest prevalence rates (FAO, 2017).Malnutrition can cause stunted growth, health concerns, and a variety of birth-related disorders, and it is especially dangerous to children and women of reproductive age. Although several vitamins and minerals are frequently deficient in human diets—iron, zinc, vitamin A, and vitamin B9 (folate). The shortages of iron, zinc, vitamin A, and vitamin B9 (folate) are among the most serious (Beall *et al.*, 2017; Straeten*et al.*, 2017).Nutritional security is essential to enhancing the health of the global populace as majority of people is primarily dependent on plant-based diets. The main source of the nutrients needed for healthy growth and development is plants. However, half of the world's population, mainly people from Asia and Africa suffer from nutrition deficiency as they rely on cereal crops for food(Vinoth and Ravindhran, 2017).

Our agricultural system hasn't been developed yet to promote human health; instead, it mainly concentrates on boosting grain yield and crop productivity. This method has caused a sharp increase in the lack of some micronutrients in cereal grains, which has increased micronutrient malnutrition among consumers. Agriculture is currently undergoing a transition from producing more food crops in greater quantities to generating enough nutrient-rich food crops (Khush*et al.*, 2012).This will aid in the fight against "hidden hunger" or "micronutrient malnutrition," particularly in underdeveloped and poorer nations whose diets are predominately composed of micronutrient-poor staple foods (Garg et al., 2018). Therefore, biofortification of many crop varieties offers a long-term and sustainable strategy for giving

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people access to crops that are high in micronutrients.By placing nutrient-dense crops at the doorsteps of underprivileged communities, biofortification is a food-based strategy to combat nutrient deprivation (Bouis*et al.*, 2011). An emerging, promising, affordable, and sustainable method of providing micronutrients to a population with limited access to diverse diets and other micronutrient interventions is biofortification.

The Biofortification Challenge Program (BCP) of the HarvestPlus-Consultative Group for International Agricultural Research (CGIAR) Micronutrients project has primarily targeted three significant micronutrients (Fe, Zn, and vitamin A) in seven major staple crops, namely rice, beans, cassava, maize, sweet potato, pearl millet, and wheat (Welch and Graham, 2004).With an average annual production of 14.2 and 12.4 million tonnes, millets, which are produced in resource-poor countries in Asia and Africa, contribute 75% of the total calorie consumption next to cereal grains (Belton and Taylor, 2004; O'Kennedy et al., 2006). About 80% of the world's millet production is produced in India, making it the top producer of millets (Food and Agricultural Organization, 2015).

Millets are commonly reffered as “small seeded grasses” which include pearl millet (*Pennisetumglaucum*), finger millet (*Eleusinecoracana*), barnyard millet (*Echinochloafrumentacea*), proso millet (*Panicummiliaceum*), foxtail millet (*Setariaitalica*), kodo millet (*Paspalumscrobiculatum*), little millet (*Panicumsumatrense*) and brown top millet (*Brachiaria ramose*) that are cultivated as food and fodder crops, primarily grown on poor and marginal lands in dry areas of temperate, subtropical and tropical regions across the globe **(Kukreti*et al.*, 2017; Rawat*et al.*, 2021)**.The millets production in the World accounts for 30.73 million tonnes, out of which 11.42 million tonnes is produced in India accounting for 37% of total World production. Nearly 60 million acres of land in India are under millet cultivation (Sakamma et al. 2018). India is the largest producer of various kinds of small millets Madhya Pradesh has highest area under small millets (32.4%) followed by Chhattisgarh (19.5%), Uttarakhand (8%), Maharashtra (7.8%), Gujarat (5.3%) and Tamil Nadu (3.9%) (Anbukkani et al. 2017). Millets are grown mainly for its grains which having high vitamins, proteins, minerals, fibre content and better than or at par with other cereals (Verma et al. 2018).

Due to their high content of proteins, dietary fibres, iron, zinc, calcium, phosphorus, potassium, vitamin B, and vital amino acids, millets are nutritionally superior to wheat and rice(Saleh *et al.,* 2013).With the exception of Golden rice, biofortified crops have generally been developed through conventional breeding that takes use of the genetic diversity present in the environment (www.harvestplus.org). When compared to other cereal crops, millets have significantly higher genetic variability for important mineral elements including iron, zinc, and calcium (Muthamilarasan and Prasad, 2015).Additionally, millets are pest- and disease-resistant crops that can withstand drought, providing excellent crop insurance in underdeveloped nations (Reddy et al., 2011). Despite millets' higher quality, India has solely prioritised pearl millet as the preferred crop for iron biofortification.

Additionally, millets crops that can withstand drought and are resistant to pests and diseases, providing good protection against crop failure in developing nations (Reddy et al., 2011). Despite millets' superior quality, India has only given pearl millet the top priority when it comes to crops for iron biofortification. As a result, there is enormous potential to use the minor millets for biofortification. Millets can be biofortified using one of two methods: either increasing the nutrient accumulation in milled grains or decreasing the antinutrients to boost the bioavailability of minerals (Vinoth and Ravindhran, 2017).

Millets Breeding

The cheapest source of iron and zinc is pearl millet, which has a wide range of these micronutrients in its germplasm. In India, biofortified (iron and zinc) pearl millet variety "Dhanashakti" and a hybrid ICMH 1201 (Shakti-1201) has been released by ICRISAT, HarvestPlus in 2014.Besides that, two varieties, ICMH 1202 (Nirmal-7) and ICMH 1301, are currently undergoing advanced farm trials. Various well-adapted commercial varieties, their progenies, and hybrids containing high content of iron and zinc in grain have been reported (Velu*et al.,* 2007; Rao *et al.,* 2012; Garg *et al.,* 2018)

Limitations of Biofortification

Limitations in Agronomic Biofortification

The simplest way of biofortification is the application of fertilisers enriched with micronutrients. Due to variations in mineral mobility, mineral accumulation among plant species, and soil compositions in the specific geographic region of each crop, agronomical biofortification's effectiveness is, however, highly variable. Agronomic biofortification is less economical and labour intensive as it demands continuous inputs, through the application of micronutrient to the soil or plant regularly (Waters and Sankaran, 2011).Furthermore, it is not always possible to concentrate the micronutrient into edible plant parts like seeds or fruits, and this can occasionally lead to the buildup of desired nutrients in the leaves or other non-edible parts of plants; therefore, this technique is only successful in certain minerals and specific plant species.Another major issue is that phytic acid, an antinutrient molecule, inhibits the bioavailability of minerals. The accumulation of fertilisers in soil and water also has negative environmental repercussions, which is the strongest constraint of all (Garg *et al.*, 2018).

Limitations in Conventional Breeding Methods

There are restrictions on the quantity of genetic diversity for the micronutrients in the plant gene pool and the period of time required to produce cultivars with the desired characteristic (s).Many times, it would be impossible to breed for a certain trait using conventional methods, and the timescale and effort necessary may be quite impractical. In some cases, this can be solved by crossing to distant relatives and therefore introgressing traits into commercial cultivars. e.g., improving Se concentration in wheat grains and improvement of oleic, linoleic, and linolenic fatty acid content in soybean. Due to the low variability, heredity, and linkage drag, transgenic-based approaches have generally produced superior results when improving oil quality (Garg *et al.*, 2018).

Limitations in Transgenic Methods

The fundamental drawback of this technology is that it is not widely accepted by the general public. Transgenic crops overcome the restriction of limited genetic variation among plants as in the case of conventional breeding(Garg *et al.*, 2018). It is important that farmers and the community accept biofortified crops quickly and in a substantial enough number to improve the community's overall nutritional health.

Conclusion and Future Prospects

It is well known that biofortification is a viable and economical agricultural approach for enhancing the nutritional status of malnourished communities all over the world. Mineral deficiency in humans has the potential to be greatly reduced by biofortification techniques based on crop breeding, targeted genetic manipulation, and/or the use of mineral fertilisers.The development of food crops that have been biofortified to include more minerals, such as increased amounts of iron, zinc, selenium, and provitamin A, is supplying adequate quantities of these and other micronutrients that are typically lacking in the diets of both poor and developed countries.In order to prevent micronutrient deficiencies, insufficient scientific research has been done on the very nutritious millet crops. The bioavailability of nutrients must be further improved by reducing antinutrients or by using innovative promoters despite the good grain characteristics and considerable levels of essential amino acids, minerals, and vitamins.Understanding the function of different transporters in nutrient uptake, transfer, and storage may aid in locating macro- and micronutrients in edible parts of millets'.Despite the obstacles, biofortified millet crops have a highly promising future as they have the power to transform the nutritional status of billions of people from nutrient deficiency to nutrient sufficiency.

References:

Anbukkani, P., Balaji, S. J. andNithyashre, M. L. (2017). Production and consumption of minor millets in India- A structural break analysis. *Ann Agric Res* 38(4):1-8.

Beall, T., Massiot, E., Arsenault, J. E., Smith, M. R. and Hijmans R. J. (2017). Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes. PLoS ONE 12, e0175554.

Bouis, H.E., Hotz, C., McClafferty, B., Meenakshi, J. V. and Pfeiffer,W.H. (2011). Biofortification: a new tool to reduce micronutrient malnutrition. *Food Nutr. Bull*. 32, S31–S40.

Dwivedi, S. L., Upadhyaya, H. D., Senthilvel, S., Hash, C.T., Fukunaga, K., Diao, X. and Prasad, M. (2012). Millets: genetic and genomic resources.35:247-375.

FAO. FAOSTAT. (2017). Food and Agriculture Organization of the United Nations.

Garg, M., Sharma, N., Sharma, S., Kapoor, P., Kumar, A., Chunduri, V. and Arora, P. (2018). Biofortified Crops Generated by Breeding, Agronomy, and Transgenic Approaches Are Improving Lives of Millions of People around the World. *Front. Nutr*. 5:12. doi: 10.3389/fnut.2018.00012.

Gupta, S.M., Arora, S., Mirza, N., Pande, A., Lata, C., Puranik, S., Kumar, J. and Kumar, A. (2017). Finger Millet: A “Certain” Crop for an “Uncertain” Future and a Solution to Food Insecurity and Hidden Hunger under Stressful Environments. *Front Plant Sci.* 8:643. doi: 10.3389/fpls.2017.00643

Khush, G.S., Lee, S, Cho, J.I. and Jeon, J.S. (2012). Biofortification of crops for reducing malnutrition. *Plant Biotechnol Rep*. 6:195–202. doi:10.1007/s11816- 012-0216-5.

Kukreti, A., Kurmanchali, N., Rawat, L. and Bisht, T.S. (2017) Evaluation of fluorescent *Pseudomonas* spp. against *Pyriculariagrisea, Rhizoctonia solani* and*Sclerotiumrolfsii* causing blast, sheath blight and foot rot diseases of finger millet (*Eleusinecoracana* L.) crop in mid hills of Uttarakhand: In vitro study. *Bull Environ Pharmacology Life Sci*. 6:29-35.

Muthamilarasan, M.,and Prasad, M.(2015). Advances in *Setaria* genomics for genetic improvement of cereals and bio energy grasses. *Theor.Appl.Genet*. 128, 1–14.

Rai, K.N., Govindraj, M. and Rao, A.S. (2012). Genetic enhancement of grain iron and zinc content in pearl millet. *Crops Food*, 4(3):119–25. doi:10.1111/j.1757-837X.2012.00135.x

Reddy, I.N.B.L., Reddy, D.S., Narasu, M. L., and Sivaramakrishnan, S. (2011). Characterization of disease resistance gene homologues isolated from finger millet (*Eleusinecoracana* L. Gaertn). *Mol. Breed.* 27, 315–328.

Sakamma, S., Umesh, K.B., Girish, M. R., Ravi, S.C., Satishkumar, M. and Bellundagi, V. (2018). Finger millet (*Eleusinecoracana* L. Gaertn.) production system: Farmer's welfare. *J AgrilSci* 10:162-179.

Saleh,A.S.M.,Zhang,Q.,Chen,J.,andShen,Q.(2013).Milletgrains:nutritionalquality,processing, and potential health benefits. *Compr. Rev.FoodSci.FoodSaf.* 12, 281–295.

Van Der Straeten, D., Bhullar, N. K., De Steur, H., Gruissem, W., MacKenzie, D., Pfeiffer, W., ...and Bouis, H. (2020). Multiplying the efficiency and impact of biofortification through metabolic engineering. *Nature Communications*, 11(1), 1-10.

Velu, G., Rai, K.N., Muralidharan, V., Kulkarni, V.N., Longvah, T. and Raveendran, T.S. (2007). Prospects of breeding biofortified pearl millet with high grain iron and zinc content. *Plant Breed* 126:182–5.

Verma, V.C., Verma, V. C., Singh, A. and Agrawal, S. (2018). Ethnobotanical study of small millets from India: Prodigious grain for nutritional and industrial aspects. *Inter J Chemical Studies* 6(4):2155-2162.

Vinoth, A. and Ravindhran R. (2017). Biofortification in Millets: A Sustainable Approach for Nutritional Security. *Front. Plant Sci*. 8:29. doi: 10.3389/fpls.2017.00029.

Waters, B.M. and Sankaran, R.P. (2011). Moving micronutrients from the soil to the seeds: genes and physiological processes from a biofortification perspective. *Plant Sci.* 180 (4): 562–74.

Welch, R. M. and Graham, R.D.(2004).Breeding for micronutrients in staple food crops from a human nutrition perspective. *J. Exp.Bot*. 55, 353–364. doi:10.1093/jxb/erh064.