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Bio-Fortification in Millets

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Introduction:

Micronutrient deficiency is a great growing threat in the developing countries. There are over two billion people suffering from micronutrient undernourishment throughout the world. India accounts for more than 25 % of the world's undernourished population. Malnutrition by deficiencies of iron, zinc, andvitamin A are at high risk. Zn and Fe deficiency causes death of about five lakhs' children less than 5 years of age annually. So, to combat these nutritional deficiencies, Agriculture must be focused not only on productivity but also on supply of quality feed to people for reducing undernourishment. Various malnutrition mitigation approachesincluding fortification, supplementation, nutrition education, dietary diversification, and more recently Bio-fortification have to be employed. So, production of staple food crops enriched with bioavailable nutrients especially iron, zinc, provitamin A, and essential amino acids is the need of the day.

What is called Bio-fortification?

Food nutrification or fortification is the improvement in quality of food by addition of supplementsto reduce nutrient deficiency in population. Fortification is the way of purposely enhancing the content of a vital micronutrient, i.e., vitamins and minerals (including trace elements), in a food to increase the nutritional quality of the food.

Millets – A better choice for Bio-fortification:

- Millets, the Nutri-cereals are the first cereal grains to be domesticated and it is the staple food of the people of semi-arid tropics of Asia and Africa.
- Millets are hardy cropswhich grow majorly as rainfed crops. They can begrown under poor and marginal soil fertility. It is highly preferred due to their higher productivity, short growing season and tolerance to dry and hightemperature.

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- They are divided in two groups, major andminor millets. The major millet includes sorghumand pearl millet. The minor millets arefinger millet, proso millet, foxtail millet, kodomillet, little millet, andbarnyard millet.
- They are many times nutritionally superior torice and wheat. They are recommended for well- being of infants, lactating mothers, elderly and convalescents. The grains release sugar slowly into the blood stream and thus considered "gluten-free".
- Pearl millet is rich in Fe, Zn, and lysine compared to other millets. Hence it is highly recommended for Bio-fortification. Foxtail millet contains a high amount of protein (11%) and fat (4%). Finger millet grains contain higher levels of minerals like Ca, Mg, and K.
- Proso millet contains the highest amount of proteins (12.5%) while barnyard millet is the richest source of crude fiber (13.6%) and Fe (186 mg/kg dry matter). With lowest carbohydrate content among the millets, Barnyard millet is recommended as an ideal food for type II diabetics.
- Kodo millet is 'bestowed with high magnesium content (1.1 g/kg dry matter). The millets are a good source of most essential amino acids, namely, methionine, lysine, and cystine.
- Hence millets have indispensable role in the food security system of the poor world. Despite these benefits this nutraceutical crop remains underutilised. Considering the nutrient richness, these millets can be biofortified to promote its production and consumption.

What are the ways to achieve bio fortification in millets?

Bio fortification in millets can be achieved through two strategies: (1) by enhancing the accumulation of nutrients in milled grains and (2) by reducing the antinutrients to increase the bioavailability of minerals.

Enhancing the accumulation of nutrients:

1. Biofortified crops have been primarily developed through conventional breeding exploiting the natural genetic variation.Micronutrient improvement characters exist within genomes that can be used for increasing micronutrient levels in the foods Millets exhibit vast genetic variability for key mineral elements like, iron, zinc, and calcium.; Hence, Conservation of plant genetic resources (PGRs) provides a

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continuous supply of raw material for crop improvement. Core and mini core corrections are being maintained at ICRISAT for all the millets.

2. Use of Recombinant DNA technology also provides solution. Introgression of nutrient-linked genes into millets can become feasible by the use of molecular breeding or genetic engineering.
3. Agronomic biofortification of food crops is an important complement to genetic biofortification.
    - Biofortification by rising micronutrient content in the seeds provides a sustainable solution to micronutrient deficiency.
    - Enhancement of the micronutrient concentration in grains of crops by addition of micronutrient containing fertilizers is one of the low-priced alternatives to tackle the problem of malnutrition.
4. Identification of molecular markers linked to nutritional traits will decipher the information on candidate genes controlling these traits. Transgenic expression of zinc transporters resulted in the development of high grain zinc while transcriptomics revealed various calcium sensor genes involved in uptake, translocation, and accumulation of calcium in finger millet.

Thus, integration of knowledge on genomics, transcriptomics, proteomics, and metabolomics could promote millets as model systems for advancements in biofortification of staple crops.

What are called Antinutrients?

- The compounds that bind to the nutrients present in the foodand make them less available for absorption by the human bodyare called anti-nutrients.
- Antinutrients commonly found in millets are phytic acid, polyphenols and tannins. They greatly reduce the bioavailability of minerals by chelating multivalent cations like Iron, Zinc, Calcium, Magnesium and Potassium. Phytic acid, the major form of phosphorus in seeds chelates the mineral cations in protein storage vacuoles. In addition, high amounts of protease and amylase inhibitors affect the digestibility of millet grains.

How to remove it?

1. Antinutrients are commonly removed by decortication, malting, germination, fermentation, roasting, flaking, and grinding. However large-scale industrial methods

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for processing of millets to produce novel functional foods are not well developed as that for other cereal crops. Reduction in antinutrients during plant growth and development is therefore a promising strategy to improve the bioavailability of minerals from nutrient-rich millets.

2. RNA interference and genome editing tools [zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and clustered regularly interspaced short palindromic repeats (CRISPR)] needs to be employed to reduce these antinutrients.
3. Recently, low phytic acid lpa mutants have been developed,which lower the phytic acid content naturally in legumesand cereals.

Fe and Zn biofortified pearl millet:

ICMH 1202 (AHB1200) ICMH 1203 (HHB299) ICMH 1301 (DHBH1211)

- Harvest Plus is a CGIAR Challenge program, has taken a global effort to breed and disseminate micronutrient-rich crop varieties including pearl millet.
- Breeding for micronutrient dense cultivars needs the screening of a large number of genetic material such as germplasm collections, elite lines, segregating populations, hybrids etc.and phenotyping for micronutrients through destructive techniques which involve high analytical cost and breeding resources.
- Atomic Absorption Spectrophotometry (AAS) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) techniques (both are destructive methods)

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are highly used by researchers, and their results are reproducible for grain Fe and Zn densities.

- Open-pollinated varieties (Dhanashakti) and hybrids (ICMH 1202, ICMH 1203 and ICMH 1301) of pearl millet with a high grain yield and high levels of iron (70–75 mg kg^{-1}) and zinc (35–40 mg kg^{-1}) densities have been developed and released first in India.
- Currently, India is growing > 70,000 ha of biofortified pearl millet. The success of this breeding program depends on the precision phenotyping efficiency through high throughput tools. This is a primary need of the biofortification research and is a key to speedy progress in identifying high-Fe/Zn lines from large set of germplasm and gene pools.

Conclusion:

To reduce the micronutrient deficiencies which is majorly prevailing on developing countries, Bio-fortification is one of the sustainable and cost-effective approaches for producing more quality food to uplift the health of the people. It is evident from the above facts that millets can be successfully biofortified for enhancing the micronutrient contents. Despite millets are called the Store house of nutrients, bio-fortification is majorly focussed on Pearl millet and very meagre on other millets. There is much increased scope of Bio-fortification on other millets too and it must be concentrated for the well-being of the planet.