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Biofortification in Millets

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Abstract

In Semi Arid tropics of Asia and Africa, millets are consider as one of the primary source of energy with good source of proteins , vitamins , minerals and essential amino acids. As due to increase in world's population, shortage of food is one of the major threat. Therefore, Bio fortification of millets can be consider as a solution to address the problem of micronutrient malnutrition. Harvest Plus initiated global crop biofortification research under several CGIAR centers on 12 crops including pearl millet, due to which Harvest Plus was recognized with the World Food Prize in 2016. Besides reducing the iron and zinc deficiencies, pearl millet has recently gaining increasing attention as a climate change-resilient and Smart Food crop on account of its high levels of tolerance to drought, heat and soil salinity along with high protein content with more balanced amino acid profile, high dietary fiber, gluten-free protein , and phyto-chemicals. Biofortification in millets can be achieved through two strategies firstly by enhancing accumulation of nutrients in millets and secondly by reducing antinutrients such as saponins, tannins, phytic acid, gossypol, lectins, protease inhibitors, amylase inhibitor, and goitrogens to increase bioavailability of minerals.

Keywords: *Biofortification, Antinutrients, Food, Deficiencies, Minerals.*

Introduction

The inadequate intake of energy-providing organic macronutrients mainly carbohydrate, protein and fats leads to mal-nutrition, with a consequent feeling of hunger. There are several micronutrients which plays vital role in various physiological functions. These micronutrient deficiencies are termed as hidden hunger primarily the result of a poor quality of diet. Deficiencies of iron (Fe) and zinc (Zn) have been reported to affect more than two billion people worldwide especially women and children, mostly in the developing countries.

Therefore, considerable global development efforts are underway to improve the health of poor people, one of them is biofortification which is breeding of staple food crops enriched with essential micronutrients to overcome the nutrient starvation by delivering nutrient-dense crops at the door steps of poor populations. This is a multidisciplinary, sustainable and cost-effective approach to bring the full potential of crop improvement and nutrition science to handle the problem of micronutrient malnutrition.

In India and Africa, millets provide 75% of total calorie intake next to cereal grains with annual production of 14.2 and 12.4 million tons (Belton and Taylor, 2004; O'Kennedy et al., 2006). Millets are nutritionally superior to cereals such as rice and wheat as they contain a high amount of proteins, dietary fibers, iron, zinc, calcium, phosphorus, potassium, vitamin B, and essential amino acids. But due to the presence of antinutrients such as phytates, polyphenols, and tannins reduce the mineral bioavailability by chelating multivalent cations like Fe^{2+}, Zn^{2+}, Ca^{2+}, Mg^{2+}, and K^{+}. In addition, the digestibility of millet grains is also affected due to presence of high amounts of protease and amylase inhibitors.

Pearl millet being highly nutritious is largely grown under rainfed conditions in India (8 m ha) and Africa (18 m ha), it is a high-iron crop with a fairly high Zn content, higher than rice and wheat; however, high content of Fe and Zn is not available in all cultivars as, the crop breeding programs in ICRISAT and the National Agricultural Research System (NARS) in India and Africa have largely been focused on the grain yield and biotic stress tolerance, and minimum importance was given to nutritional quality traits (iron and zinc). Therefore, the thrust of pearl millet biofortification research targeted for India is on the development of high-yielding and high-Fe hybrids, since the entire efforts in the public and private sector are more toward hybrid development.

Nutritional significance of millets:

- Millets are highly nutritious and are rich source of proteins, vitamins, and minerals. About 80% of millet grains are used for food, and 20% being used as animal fodder and in brewing industry for alcoholic products.

- The grains release sugar slowly into the blood stream and thus considered "gluten-free".
- High fiber and protein content make millets more preferable as dietary foods for people with diabetes and cardiovascular diseases.
- They also contain health promoting phenolic acids and flavonoids, which plays vital role in combating free-radical mediated oxidative stress and helps in lowering blood glucose levels.
- Pearl millet is rich in Fe, Zn, and lysine (17–65 mg/g of protein) as compared to other millets.
- 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).
- Barnyard millet grains possess other functional constituents' viz. γ-amino butyric acid (GABA) and β-glucan. With lowest carbohydrate content among the millets, barnyard millet is recommended as an ideal food for type II diabetics.

Biofortification in millets can be achieved through two strategies:

- By increasing the accumulation of nutrients in milled grains and
- by reducing the antinutrients such as phytates, polyphenols, and tannins to increase the bioavailability of minerals.

Biofortification Breeding Approach :

Biofortification breeding program in pearl millet at ICRISAT has taken a three-breeding phase-I, II and III. The first phase is a short-term approach which deals withthe traits genetics, screening of germplasm and creation of genetic variability. The second phase is the medium-term approach consisting of validation of identified high-iron and zinc breeding lines and to develop fast-track biofortified variety/hybrids. The third phase consisted of long-term objective of development high-Fe/Zn breeding lines and hybrid parents and its genetic diversification through breeding programs.

Biofortified Cultivar Release and Adoption :

A world first high-Fe pearl millet variety 'Dhanashakti' was developed by utilizing the intra-population variability within ICTP 8203, an early-maturing, large-seeded, disease resistant and high-yielding open-pollinated variety that has been under cultivation in India since 1990. Dhanashakti is officially released and notified by Central Variety Releasing

Committee in 2014 for the cultivation in all pearl millet growing states of India. Based on national testing trials, Dhanashakti had 71 mg kg^{-1} Fe (9% higher) and 2.2 t ha^{-1} grain yield (11% higher) compared to the original. The first biofortified variety Dhanashakti reached nearly 90,000 famers in India. ICMH 1201 and eight other biofortified hybrids developed at ICRISAT and have been tested over two years in the All India Coordinated Research Project on Pearl Millet (AICRP-PM) trials.

Reduction of antinutrients:

Antinutrients are the compounds that bind to the nutrients present in the food and make them less available for absorption by the human body such as phytate, polyphenols, tannins, enzyme inhibitor etc. There are several reduction strategies which have been used for many years to reduce the concentration of anti-nutrients.

1. **Decortication** : Decortication or dehulling involves the removal of the pericarp (outer covering) of the grains. Various millets different fraction of husk ranging from 1.5 to 29.3%. Decortication reduced phytic acid up to 53% and total polyphenolic content (TPC) up to 9% in pearl millet.
2. **Heating :** Heating includes roasting, boiling, cooking, or autoclaving. Roasting reduced 74.6, 28.4, 98.3, and 97.5% of tannin, phytate, trypsin inhibitor, and protease inhibitor, respectively. Abdelrahman et al. found that cooking caused a 6-10% and 5-8% reduction in phytic acid and polyphenols.
3. **Soaking** : Some studies reported that soaking in water for 12 to 18 hours is quite efficient in reducing levels of partially or entirelysoluble phytic acid and proteolytic enzyme inhibitors. Hithamani and Srinivasan, studied a reduction in tannins content from 2.72 to 0.70 mg/g after soaking. During soaking, the enzyme polyphenol oxidase gets activated, which reduces the polyphenolic content.
4. **Germination** : It could improve millet nutritional content by modifying the composition of chemicals and reducing the anti-nutrient factors. When pearl millet grains are germinated for 24 hrs at 30˚C, it leads to a reduction of phytates by more than 50%. This is due to the activity of an endogenous enzyme called phytase which hydrolyzes phytic acid and eventually reduces phytic acid content.
5. **Fermentation :**It eliminates certain endogenous anti-nutritional factors and has a positive effect on protein digestion and bioavailability. In a study, Rasane et al.

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observed that non-fermented roasted and germinated pearl millet samples have high phytic acid content than fermented, roasted, and germinated samples.

Conclusions:

Biofortification is scientific, sustainable and cost-effective approach to address malnutrition. Combining the yield and micronutrients is highly feasible, like other heritable traits provided the mainstreaming of these traits in the national and international breeding programs. Public and private partners need to take this opportunity to elevate the importance of this nutri-cereal at a national and international level. Efficacy studies provide evidence that the consumption of grains from biofortified varieties would provide bioavailable Fe to meet a fully recommended daily allowance (RDA) in children, adult men and 80% of the RDA in women. In the modern era, genetic biofortification is a way of improving nutrition in staple crops for which enhanced food processing and markets will be the backbone to nutritional security in the future. There is no regulatory mechanism in place to support biofortified crop varieties, and markets are the key for enhancing processed foods, as are related industries. This will also generate market opportunities for farmers. Biofortified pearl millet has the potential to make significant contributions to the food-cum-nutritional security in dryland poor households. Biofortified cultivars are being developed through conventional breedingeither by increasing the accumulation of nutrients in milled grains or by reducing the antinutrients such as phytates, polyphenols, and tannins to increase the bioavailability of minerals .

Reference :

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