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Biofortification of Crop for Nutritional Security

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"Biofortification" or "biological fortification" refers to nutritionally enhanced food crops with increased bioavailability to the human population that are developed and grown using modern biotechnology techniques, conventional plant breeding, and agronomic practices. The United Nations Food and Agriculture Organization has estimated that around 792.5 million people across the world are malnourished, out of which 780 million people live in developing countries. The biofortified food crops, especially cereals, legumes, vegetables, and fruits, are providing sufficient levels of micronutrients to targeted populations. Malnutrition has emerged as one of the most serious health issues worldwide. Caused due to consumption of unbalanced diet poor in nutritional quality this is more prevalent in the underdeveloped and developing countries. Biofortification is the development of nutrient-dense staple crops using the best conventional breeding practices and modern biotechnology, without sacrificing agronomic performance and important consumer-preferred traits. The primary aim of biofortification is to increases the nutritional quality of crops during plant growth rather than during processing of crops. As compared with conventional (non-biofortified crops), biofortified crops have better yield, resistance to pests, diseases and tolerance to stresses which ultimately help to improve food safety and nutrition security among community.

Biofortification can be carried out using different techniques like agronomical biofortification, conventional plant breeding and by use of genetic modification with the focus to increase the level of nutrients (iron, zinc, β-carotene, amino acids) in different crop varieties like beans, cassava, maize, rice, wheat, sweet potato and pearl millet etc.

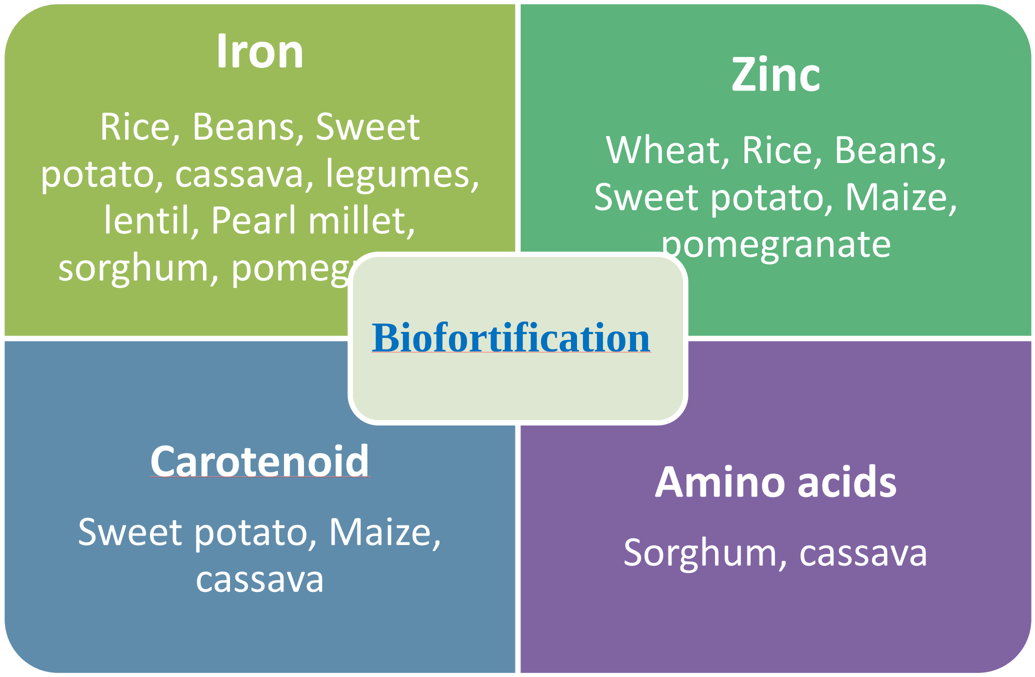


Fig. 1: Common examples of biofortification

Importance of biofortification

- Biofortified crops are rich source of nutrients like iron, zinc, amino acids, carotene and many vitamins have potential to improve food safety and nutritional status and in improving the overall health of human.
- Biofortified crops are also often more resilient to pests, diseases, higher temperatures, drought and provide a high yield.
- Biofortification fills an important gap as it provides a food-based, sustainable and low-dose alternative to iron supplementation. It does not require behavior change, can reach the poorest sections of the society, and supports local farmers.
- After the initial investment to develop the biofortified seed, it can be replicated and distributed without any reduction in the micronutrient concentration. This makes it highly cost-effective and sustainable.
- Considering the various implementation barriers faced by genetically modified crops in India, biofortification which can be done through non-genetically-modified methods as well can be a better alternative.

Biofortified varieties:

Rice

1. **CR Dhan 310:** Contains high protein (10.3%) in polished grain developed by ICAR-National Rice Research Institute, Cuttack, Odisha.
2. **DRR Dhan 45:** High in zinc (22.6 ppm) in polished grain developed by ICAR-Indian Institute of Rice Research, Hyderabad, Telangana.
3. **DRR Dhan 49:** It is a pure line variety with high zinc (25.2 ppm) in polished grain. Developed by ICAR-Indian Institute of Rice Research, Hyderabad, Telangana.

Wheat

1. **WB 02:** It is a pure line variety and rich in zinc (42.0 ppm) and iron (40.0 ppm). Developed by ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana.
2. **HPBW 01:** It is a pure line variety and contains high iron (40.0 ppm) and zinc (40.6 ppm). Developed by Punjab Agricultural University, Ludhiana, Punjab, under ICAR-All India Coordinated Research Project on Wheat and Barley.
3. **Pusa Tejas (HI 8759):** High in protein (12%), iron (42.1 ppm) and zinc (42.8 ppm). suitable for making *chapatti* (Indian bread), pasta and other traditional food products. developed by ICAR-Indian Agricultural Research Institute (IARI), Regional Station, Indore, Madhya Pradesh.
4. **Pusa Ujala (HI 1605):** High in protein (13%), iron (43 ppm) and zinc (35 ppm) and having excellent *chapatti* making quality. It is developed by ICAR-IARI, Regional Station, Indore, Madhya Pradesh.
5. **MACS 4028 (d):** High in protein (14.7%), iron (46.1 ppm) and zinc (40.3 ppm). It is developed by Agharkar Research Institute, Pune, Maharashtra, under ICAR-All India Coordinated Research Project on Wheat and Barley

Maize

1. **Pusa Vivek QPM9 improved:** It is high in provitamin-A (8.15 ppm), high tryptophan (0.74%) and lysine (2.67%) in endosperm protein and known as 'quality protein maize' (QPM). developed by ICAR-IARI, New Delhi.

2. **Pusa HM4 improved:** It is high in tryptophan (0.91%) and lysine (3.62%) in endosperm protein. It is developed by ICAR-IARI, New Delhi.
3. **Pusa HM8 improved:** It is high tryptophan (1.06%) and lysine (4.18%) in endosperm protein. Developed by ICAR-IARI, New Delhi.
4. **Pusa HM9 improved:** It is high tryptophan (0.68%) and lysine (2.97%) in endosperm protein. Developed by ICAR-IARI, New Delhi.

Pearl millet

1. **HHB 299:** It is a hybrid and possesses high iron (73.0 ppm) and zinc (41.0 ppm) content. Developed by Chaudhary Charan Singh-Haryana Agricultural University, Hisar in collaboration with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad, Telangana, under ICAR-All India Coordinated Research Project on Pearl millet.
2. **AHB 1200:** It is a hybrid and rich in iron (73.0 ppm). developed by Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, in collaboration with ICRISAT, Patancheru, Hyderabad, Telangana, under ICAR-All India Coordinated Research Project on Pearl millet.
3. **Dhanshakti** the first iron biofortified pearl millet variety contains 71 mg/kg iron and 40 mg/kg zinc. Pearl millet with low erucic acid content.

Lentil

1. **Pusa Ageti Masoor:** It is a pure line variety and contains 65.0 ppm iron. developed by ICAR-IARI, New Delhi.
2. **IPL 220:** It is a pure line variety with high iron (73ppm) and zinc (51 ppm). Developed by ICARIndian Institute of Pulses Research, Kanpur, Uttar Pradesh.

Mustard

1. **Pusa Mustard 30:** It is a pure line variety and contains low erucic acid (<2.0%) in oil. developed by ICAR-IARI, New Delhi.

2. **Pusa Double Zero Mustard 31:** variety and contains low erucic acid (<2.0%) in oil and glucosinolates (<30.0 ppm) in seed meal. developed by ICAR-IARI, New Delhi.
3. **Pusa Beta Kesari 1:** Country's first biofortified cauliflower contains high β-carotene (8.0-10.0 ppm) in comparison to negligible β-carotene content in popular varieties. Developed by ICAR-Indian Agricultural Research Institute, New Delhi.

Soybean

1. **NRC-127:** It is a KTI-free pure line soybean variety. Developed by ICAR-Indian Institute of Soybean Research, Indore, Madhya Pradesh.

Cauliflower

1. **Pusa Beta Kesari 1:** It is a pure line variety and contains high β-carotene (8.0-10.0 ppm). Developed by ICAR-IARI, New Delhi.

Sweet potato

1. **Bhu Sona:** It is a pure line variety and contains high β-carotene (14.0 mg/100 g). It has been released and notified in 2017 for Odisha. developed by ICAR Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala.
2. **Bhu Krishna:** It is a pure line variety and contains high anthocyanin (90.0 mg/100 g). Developed by ICAR-CTCRI, Thiruvananthapuram, Kerala.

Pomegranate

1. **Solapur Lal:** contains high iron (5.6-6.1 mg/100 g), zinc (0.64-0.69 mg/100 g) and vitamin C (19.4-19.8 mg/100 g) in fresh arils. developed by ICAR-National Research Centre on Pomegranate, Pune, Maharashtra.

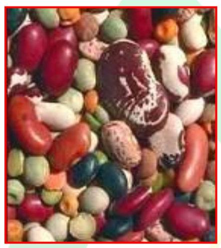
Carrots

1. **Madhuban Gujar:** This is high in β-carotent content (277.75mg/kg) and iron content (276.7 mg/kg) developed by Shri Vallabhhai Vasrambhai Marvaniya, a fermer scientist from junagadh district, Gujrat. Used for value added products like carrot chips, juices and pickles**.**

Potato:

1. **Bhu Sona:** contains high β-carotene (14.0 mg/100 g) content as compared to 2.0-3.0 mg/100 g β- carotene in popular varieties. Developed by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala Sweet.
2. **Bhu Krishna:** High in anthocyanin (90.0 mg/100g) content in comparison to popular varieties which have negligible anthocyanin content. Developed by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.

Sweet potato



Beans

Maize

Rice

Cassava

The Prime Minister of India recently dedicated to the nation, 17 recently developed biofortified varieties of 8 crops will have up to 3.0-fold increase in nutritional value. The rice variety **CR Dhan 315** has high zinc; wheat variety **HI 1633** rich in protein, iron and zinc, **HD 3298** rich in protein and iron and **DBW 303** and **DDW 48** rich in protein in wheat; Ladhowal Quality Protein Maize Hybrid 1, 2 and 3 rich in lysine and tryptophan; CFMV1 and 2 of finger millet rich in calcium, iron and zinc; CLMV1 of little Millet rich in iron and zinc; Pusa Mustard 32 with low erucic acid; Girnar 4 and 5 of groundnut with enhanced oleic acid and yam variety Sri Neelima and DA 340 with enhanced zinc, iron and anthocyanin content. The National Agricultural Research System under the leadership of Indian Council of Agricultural Research (ICAR) has developed 53 such varieties during the last five years.

Global impact of biofortified varieties

The deployment of biofortified cultivars holds great promise for health and wellbeing of the human population. Several studies have demonstrated the positive effects of these biofortified crops on humans. A study conducted on 246 children of 12-16 yr of age in Maharashtra, by feeding them with '*bhakri*' (round flat unleavened bread) made from iron-rich and conventional pearl millet grains, demonstrated that feeding iron-rich pearl millet was an efficient approach to improve iron status in school-age children28. In another, serum xanthophylls and retinol were significantly improved in Zambia children fed with provitamin-A rich maize grains29. In a study on 679 Zambian children, it was found that consumption of β-carotene-rich maize significantly improved their serum β-carotene concentrations compared with traditional maize30. The beneficial effects of QPM are also well-demonstrated worldwide. Porridge made from QPM resulted in fewer sick days among children compared to those who had porridge from normal maize. Infants and young children fed with QPM expressed 12 per cent higher rate of growth in weight and nine per cent in height compared to the group given only normal maize31. Another study showed that consumption of 100 g QPM was sufficient for children to meet the requirement of lysine resulting into reduction in maize to the tune of 40 per cent relative to normal maize32. The orange-fleshed sweet potatoes (OFSP) were fed to South African school children aged 5-10 yr, and a favourable response in the vitamin-A status of children was observed compared with the children fed with a traditional white variety of sweet potato33. In Mozambique, children who consumed OFSP over the two-year intervention possessed significantly higher serum retinol concentrations compared with non-intervened children34. The development and promotion of biofortified varieties thus would be helpful in addressing malnutrition and achieving the SDGs.

References:

Howarth E. Bouis and Ross M. Welch (2010). Biofortifi cation—A Sustainable Agricultural Strategy for Reducing Micronutrient Malnutrition in the Global South, Crop science, Vol. 50, March–April 2010.

Monika Garg*, Natasha Sharma, Saloni Sharma, Payal Kapoor, Aman Kumar, Venkatesh Chunduri and Priya Arora Biofortified Crops Generated by Breeding, Agronomy, and Transgenic Approaches Are improving Lives of Millions of People around the world, February 2018 | Volume 5 | Article 12, Frontiers in Nutrition.

Nutritional security through crop biofortification in India: Status & future prospects Devendra Kumar Yadava, Firoz Hossain & Trilochan Mohapatra, Indian J Med Res 148, November 2018, pp 621-631.

Lockyer S, White A, Walton J et al. (2018) Proceedings of the 'Working together to consider the role of biofortification in the global food chain' workshop. Nutrition Bulletin 43: 416–27