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Biofortification – A Promising Strategy for Nutritional Security

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Abstract *The Green Revolution that began in the 1940s and 50s brought about large increases in crop yields and saved millions of people from mass famine. Yet malnutrition remains widely prevalent around the globe. And, while many people eat enough calories, many do not get enough nutrients. Resulting in many nutritional deficiencies like iron, vitamin a, folic acid etc. and NCD diseases like diabetes, obesity, cancers and cardiovascular diseases. There is a need for multiple complementary strategies to address these key nutritient deficiencies. Biofortification represents one promising strategy to enhance the availability of vitamins and minerals for people whose diets are dominated by micronutrient-poor staple food crops. This paper presented a view about biofortified crops, its history, development of varieties in various crops and there nutritional benefits.*

Key words: *Biofortification, nutritional deficiencies like iron, vitamin a, folic acid*

Introduction: In India even after 70 years of Independence, malnutrition continues to plague in rural sectors. Even though majority of resource-poor people suffer from undernutrition, there is a growing incidence of obesity and chronic diseases like diabetes, cardiovascular diseases, cancer etc. due to several factors including changing food habits and loss of millets from the diet. There is a need for multiple complementary strategies to address key micronutritient deficiencies. Biofortification represents one promising strategy to enhance the availability of vitamins and minerals for people whose diets are dominated by micronutrient-poor staple food crops. It involves the identification of varieties of a crop that naturally contain high densities of certain micronutrients. Plant breeders use these varieties to develop new, productive and 'biofortified' crop lines for farmers to grow, market and consume. A healthy diet is considered to be one that satisfies human needs for energy and all essential nutrients (FAO 2004). Maintaining access to diversity of foods is not easy for poor populations. Many are constrained by income level or distance to markets to eating a monotonous nutritionally inadequate diet consisting largely of one staple cereal or root crop (FAO/WHO 2014). Micronutrient deficiencies are common. Roughly one third of the world's population suffers deficiencies of vitamins (particularly A and C) and minerals (such as zinc, iodine and iron), which result in health effects that range from mild to life-threateningly severe (GNR 2014). Deficiencies in lesser-known but equally important nutrients like selenium, copper, or vitamins E and K, also carry serious health threats. Such needs often go unidentified and unaddressed until a medical condition associated with the deficiency manifests itself. Because of this invisibility, such deficiencies are widely referred to as 'hidden hunger'. Micronutrient deficiencies particularly affect poor rural populations in low and middle income countries. But, perhaps surprisingly, micronutrient deficiencies are also associated with the growing problems of overweight and obesity, and with noncommunicable diseases (Via 2012). This is because a low quality diet tends to be nutrient-poor whether based on highly processed foods from which nutrients have been removed during processing, or on nutrient-poor foods in food insecure environments (Oddo et al. 2012; AitsiSelmi 2014).

Biofortification

Fortification is the practice of deliberately increasing the content of an essential micronutrient, i.e. vitamins and minerals (including trace elements) in a food, so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health. Biofortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology. Biofortification differs from conventional fortification in that biofortification aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops. There is substantial natural variation of micronutrient content (e.g. iron) in many staple crops, including maize, beans, cassava, rice and millet. In biofortification, conventional crop breeding techniques are used to identify varieties with particularly high concentration of desired nutrients. These are cross-bred with high yielding varieties to develop biofortified varieties that have high levels of, for instance, zinc or betacarotene, in addition to other productivity traits desired by farmers. Some research has also been focused on improving micronutrient levels in crops through using transgenic methods when, for instance, natural variation in micronutrient content does not exist across varieties of a particular staple crop. In such cases, genes can be transplanted across species. This approach can involve considerable time and cost to ensure efficacy and food and environmental safety, and political debates about the use of transgenic crops for human consumption have slowed acceptance of transgenic varieties. Conventional breeding does not because it ensures a faster route to getting biofortified crops into the hands of farmers. All biofortified crops released to date (and those currently in development by HarvestPlus) are conventionally bred. An important principle applied in the breeding process is to avoid compromising yield potential of biofortified varieties since this could make them less desirable to producers. Since biofortification is aimed at the rural poor, who often live in remote marginal environments and consume most of the staple foods they produce, adoption of biofortified varieties increases the chance that their micronutrient needs can be met, even if other interventions are not reaching them. As a result, the potential for nutritional impact on a very large scale at relatively low cost has been cogently argued (Nestel et al. 2006; Stein et al. 2008), and many developing country governments have since invested in promoting biofortified seeds.

History and Development of biofortified crops

The following outline covers a small selection of the many varieties that have so far been biofortified through public research organizations and released for open access in 27 developing countries to date. Reference is made to some of the studies that have confirmed the nutritional value and cost-effectiveness of such crops: High-iron bean varieties are now being disseminated in Rwanda, Uganda and the Democratic Republic of Congo. In addition to having a higher iron content than traditional varieties, preliminary evidence shows that biofortified beans can improve iron status in Rwandan women (Haas et al. 2014). Acceptability (to taste) and uptake by farmers exposed to the new varieties have been good. Orange flesh sweet potato contains high levels of betacarotene (a building block for vitamin A). Tests show that 75% of the betacarotene is retained in the potato even after boiling in preparation for a meal (HarvestPlus 2014a). Consumer acceptability and nutritional impacts have been widely documented; that is, higher vitamin A status among consumers in some contexts (Hotz et al. 2012), and higher betacarotene concentrations in others (van Jaarsveld et al. 2005; Jamil et al. 2012). Cassava varieties with high levels of betacarotene are called yellow or golden cassava. These varietals were released in 2013 in Nigeria, where 100 million Nigerians eat cassava daily. Consuming yellow cassava has been shown in one small study to have small but significant improvements in vitamin A status of children (Talsma 2014). Currently, more than 500,000 farmers have received and planted this biofortified cassava (HarvestPlus 2014d). Human studies of nutritional impact are ongoing. Maize with high betacarotene traits has been shown to be as efficacious as supplements (Gannon et al. 2014). Varieties of this orange maize were released in Zambia in 2012. They yield at least as well as traditional varieties and have been shown to have nutritional impact (de Moura et al. 2014). Biofortification has been highlighted in Zambia's National Food and Nutrition strategy, and has received strong government support, including tastings by members and staff of the Zambian Parliament. Rice biofortifed with zinc was released to farmers in Bangladesh in 2013 (Chowdhury 2014). The country's first biofortified rice varieties have a zinc content that is 30% higher than local varieties (HarvestPlus 2014a). The new rice matures faster than some traditional varieties and contains the zinc in the endosperm rather the outer periphery of the grain, which is usually lost to the consumer when rice is polished. The capacity to scale up high-zinc rice has still to be demonstrated, but if widely planted and consumed in poor households, it could contribute significantly to meeting zinc requirements in countries like Bangladesh, where the poor consume large amounts of rice daily and often sacrifice the consumption of other more nutrient-rich foods as a result. Because of its significance to poor consumers in Asia and parts of Africa, and because rice shows low natural variation or complete absence in some micronutrients, rice has been a particular target of transgenic approaches to micronutrient enhancement. Biofortified pearl millet, with higher iron and zinc content, is already being grown widely in Maharashtra, India. Studies showed that porridges or breads made with this new pearl millet provide a significant amount of iron and zinc (HarvestPlus 2014d). Iron biofortified millet has been shown to improve the iron status of school-aged children (Beer et al. 2014). Agriculture has enormous potential to support improvements in nutrition (Global Panel 2014). In the past, much agricultural policy has focused successfully on increasing the productivity of staple crops, and this has supported increased supply as well as affordability by driving down prices for consumers.

Advantages

- Once higher levels of nutrients have been bred into staple crops, they remain present in the plants' seeds or cuttings for many years.
- Adopting varieties of these crops bred for high levels of micronutrients delivers nutritional benefits generation after generation, and can reach particularly the rural poor who grow the food staples which they consume.
- Once biofortified crops are part of national food systems, recurrent costs are low and production is sustainable.
- Provides a feasible means of reaching undernourished populations in relatively remote rural areas, delivering naturally fortified foods to people with limited access to commercially marketed fortified foods that are more readily available in urban areas.
- When combined with interventions that promote dietary diversification, commercial fortification through food processing biofortifed crops can contribute to resolving nutrient deficiencies at a significant scale.

Conclusion

The challenge is no longer the science of biofortification – we know it works; our challenge as policy-makers is to scale up biofortified crops to reach millions of households through institutional, regulatory and financial policy. Moreover, biofortified crops are relatively easy to incorporate into national programmes for improving food production and nutrition security.

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