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Biofortification: A Promising Way to Alleviate Malnutrition

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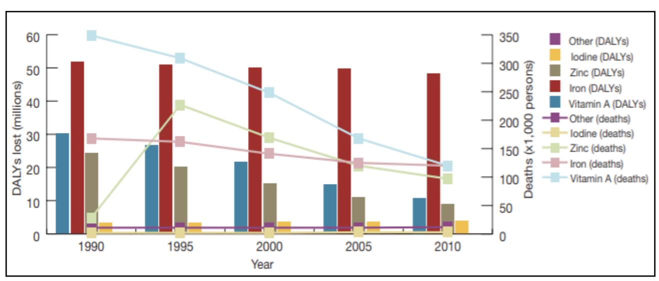
Abstract

Regular consumption of biofortified crops in developing countries where micronutrient deficiency is common has been shown to increase micronutrient intakes and thus help meet the World Health Organization's dietary recommendations. In terms of micronutrient status, most research has been conducted using provitamin A-biofortified crops (particularly orange sweet potato), with large 2 to 3 years studies indicating increases in plasma retinol, though additional studies measuring change in body stores would provide more definitive evidence. There is some evidence to suggest that iron-biofortified crops can increase iron status (measured by serum ferritin and total body iron), but further studies are required to demonstrate the efficacy of zinc-biofortified foods.

Introduction

Biofortification is the idea of breeding crops to increase their nutritional value. This can be done either through conventional selective breeding, or through genetic engineering. Biofortification differs from ordinary fortification because it focuses on making plant foods more nutritious as the plants are growing, rather than having nutrients added to the foods when they are being processed. This is an important improvement on ordinary fortification when it comes to providing nutrients for the rural poor, who rarely have access to commercially fortified foods.

The objective of biofortification is to develop micronutrient dense staple crops to achieve provitamins A, iron and zinc concentrations that can have a measurable impact on nutritional status. To get rid of malnutrition, and to enhance nutritional value of grains, Fertilization is also one of the key points of nutrient management in agronomic approaches, which enhances crop quality and produce. Application of Zn containing fertilizers to enhance the Zn content in the rice grain seems to be the possible solution for this problem.



Source: Compilation based on IHME Global Burden of Disease database

Figure 1: The global burden of micronutrient malnutrition. The number of DALY (Disability Adjusted Life Years) and deaths attributable to deficiencies of key vitamins and minerals as risk factors

Examples of biofortification projects include,

- Iron-biofortification of rice, beans, sweet potato, cassava and legumes;
- Zinc-biofortification of wheat, rice, beans, sweet potato and maize;
- Provitamin A carotenoid-biofortification of sweet potato, maize and cassava; and
- Amino acid and protein-biofortification of sourghum and cassava.

Great progress has been made in increasing vitamin content in staple crops by metabolic engineering. Although enhancing vitamin bioavailability could further improve their nutritional quality, vitamin engineering strategies to date have mostly relied on the accumulation of target compounds. Often, genes originating from nonrelated organisms, such as other plant species, mammals and/or bacteria, are overexpressed in the target crop. The best known example is Golden Rice.

Golden Rice

Golden Rice, was engineered with transgenes from daffodil and the bacterium *Pantoea* (formerly known as *Erwinia*). Golden Rice opened the door for the creation of other pro-vitamin A- enriched staple crops, such as corn, cassava, potato and wheat. Golden Rice is a GM crop intended to increase dietary vitamin A. A serious health problem in developing countries, vitamin A deficiency can lead to blindness and premature death. Rice, a food staple produces geranylgeranyl diphosphate (GGPP), an early precursor of beta-carotene. The whole beta-carotene biosynthesis pathway (2 daffodil genes and 1 bacterium gene) was engineered with into rice endosperm to convert the GGPP to beta-carotene. The product, Golden Rice, yields 1.6-2.0 µg beta-carotene/g of dry rice. Beta-carotene is not toxic and can be stored by body. The body converts beta-carotene into Vitamin A, which is toxic at high levels. Golden Rice has potential to be a valuable asset against global Vitamin A deficiency.

Folate Rice

Another well-known example is folate (vitamin B9) -enhanced rice. Here, transgenes from Arabidopsis were overexpressed in rice endosperm, which resulted in a 100-fold increase in folate content.

Multi-Biofortification

A multi-biofortification approach is necessary to optimally tackle micronutrient deficiencies. Multivitamin white corn, with enhanced beta-carotene, folate and ascorbate levels, sets a good example toward this goal, as well as mineral-enriched rice, where the over expression of a single rice gene, resulted in enhanced iron, zinc and copper content.

Conclusion

Biofortification is an approach to preventing micronutrient deficiency that is sustainable and scalable: it now reaches more than 15 million people in initial focus countries in Africa and Asia. Cumulatively, more than 100 biofortified varieties across ten crops have been released in 30 countries, where second and third waves of even higher nutrient lines are being tested for future release. It is a nutrition-smart agricultural intervention supported by robust scientific evidence demonstrating that regular consumption of traditionally cooked biofortified food crops improves the nutritional status of the most vulnerable groups: rural and marginal-urban, poor women of child bearing age (pregnant or not) and children aged 0 to 24 months.

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