Biotech In focus

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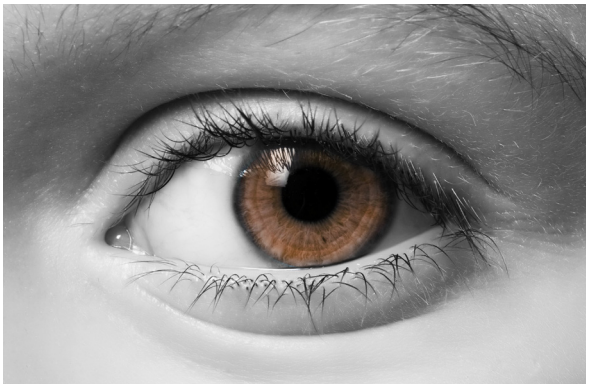
Golden Rice: Genetic Engineering to Boost Nutrition

Do you remember as a child being told to eat your vegetables? Most yellow, orange, and leafy green vegetables contain beta-carotene, which our bodies can turn into Vitamin A. Some fruits, including mangoes and papayas, also provide beta-carotene. In the developed world, Vitamin A is abundant. Vegetables and fruits are available year-round, and many foods contain preformed Vitamin A that was made by animal sources or added as a supplement. In many areas of the world populations subsist on just cereal grains with rare seasonal supplements of fruits and vegetables and some animal and fish protein.

In much of the developing world, however, Vitamin A deficiency is common and deadly. Lack of Vitamin A leads to night blindness, dry eyes (xerophthalmia), a weakened immune system, and impaired iron metabolism. Young children and pregnant or nursing women are at greatest risk for Vitamin A deficiency. The World Health Organization (WHO) estimates that 190–250 million preschool children and 19 million pregnant women worldwide don't get enough Vitamin A.



Annually, about 500,000 children are blinded by eye damage resulting from severe Vitamin A deficiency; half of these children die within 12 months. Vitamin A deficiency is linked to between 2 and 3 million childhood deaths each year, because even mild deficiency makes the body less able to fight infections. Universal access to adequate Vitamin A might prevent 23–34 percent of deaths in children under age five and up to 40 percent of maternal deaths.

Vitamin A deficiency would be rare if the world's poorest citizens had more nutritious foods to eat, but new solutions to global poverty will not come soon enough to save millions of children from preventable disability and death. Short-term fixes include delivering high-dose Vitamin A supplements to new mothers after delivery and to young children, often at the same time they are vaccinated. However, these efforts are hampered by logistics: it's hard to reach many of the people most in need, and vitamin supplements must be taken regularly to be effective.

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A Different Approach

Since the 1980s, plant scientists have sought to use genetic engineering in a different approach to Vitamin A supplementation, one that takes advantage of the ability of plants to produce beta-carotene. Rice is the staple food for about 3 billion people, many of whom are at risk for Vitamin A deficiency. To increase the availability of Vitamin A to this population, researchers developed rice that makes beta-carotene in its edible grains.

Because the raw materials for beta-carotene are already present in rice grains, adding only two genes—one from daffodil or corn and one from a soil bacterium—produced beta-carotene in the starchy part of the grain. The resulting rice appears yellow when milled. Milling removes the hard fibrous husk and bran layers, and the germ, and helps prevent spoilage though the process leads to loss of dietary fiber and some vitamins.

A second-generation Golden Rice variety produced in 2005 contains enough beta-carotene to potentially combat Vitamin A deficiency. A study conducted in the People's Republic of China and published in 2012 found that one bowl of Golden Rice provides about 60 percent of a grade-school-aged child's daily Vitamin A requirement. The rice's beta-carotene converts to Vitamin A as efficiently as a beta-carotene supplement in oil and more efficiently than beta-carotene in spinach leaves.

Beta-carotene Trait

The International Rice Research Institute (IRRI) is currently using conventional breeding to introduce the GM beta-carotene trait into popular, locally adapted rice varieties. Once this GM rice is approved by regulatory agencies in countries where Vitamin A deficiency is common, IRRI will make it available free of charge to low-income farmers, who will be able to grow, save, consume, replant, and locally sell it.

Controversey

Controversies surround genetic engineering, and Golden Rice is no exception. The 2012 bioavailability study mentioned above did not properly inform parents that the rice was genetically engineered. As a result, the study's China-based authors lost their jobs, and Tufts University banned another author from conducting research on human subjects for two years.

Continuing Trials

No children were harmed but benefitted from vitamin enhanced rice in this study with the Chinese press playing the Anti-American card in its reporting. Recently on August 8, 2013, activists destroyed rice plants growing in a field trial plot in the Philippines; other plots survived, and the field trials continued. The WHO estimates that 4.4 million Filipino children have vitamin A deficiency.

Golden Rice has been criticized by some opponents as a Trojan horse created to pressure wider adoption of GM foods, while some advocates of Golden Rice accuse those resisting its adoption of contributing to millions of needless deaths and blindness. Golden Rice is one the approaches together with diversifying diets and less effective food fortification and pill supplements to attempt to eliminated malnutrition in the most at risk populations. Food fortification and pill supplements are less effective as the poor would need to buy the fortified food and the vitamin pills. As of November 2014, no developing nations have registered Golden Rice for commercial production. For now, the ultimate success or failure of this decades-long project remains an open question.

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