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Provitamin-A Biofortified Golden Rice Approved for Commercial Cultivation in Philippines - A Breakthrough in Fighting Hidden Hunger

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Abstract

More than three decades have passed since vitamin A deficiency (VAD) has been recognized as a severe public health concern, as white rice provides no micronutrients. This issue is particularly acute in countries where rice is the staple food. Golden rice is a public-sector product designed as an additional intervention for VAD, having one gene from maize and the other from a relatively common soil bacteria. The journey of golden rice from the laboratory to the field has taken a long time. It has been legally recognized as safe as food, feed, or processed form in four industrialized countries, while approval applications are pending for underdeveloped nations. In the Philippines, the Filipino farmers will be the first in the world who able to grow golden rice for daily consumption, which might potentially eliminate child malnutrition.

Introduction

In the human body, vitamin A is essential for various activities, including the development and operation of the visual system and the immune system. Vitamin A deficiency (VAD) affects an estimated 190 million children and 19 million pregnant women. Over a million youngsters go blind every year due to VAD. In the Philippines, VAD rates vary from 19.6-27.9% in babies and pre-schoolers. In Bangladesh, 56.3% of pre-schoolers and 53.3% of school-age children display at least a moderate grade of VAD. Biofortification enhances the nutritional value of crops by increasing their nutritional content. In order to generate beta carotene, which is not typically produced in rice, golden rice is genetically engineered. When digested by the human body, beta-carotene is converted to Vitamin A. Vitamin A is essential for healthy skin, immune system, and eyesight. Deficiency of vitamin A (VAD) is common in developing nations, whose diets are dominated by rice and other carbohydrate foods deficient in micronutrients and do not include vitamin A. According to the World Health Organization (WHO), nearly 250 million preschool children are afflicted by VAD, and about 2.7 million children die due to this deficit, according to World Health Organization (WHO).

Approx. two billion individuals worldwide suffer from hidden hunger caused by a lack of vital minerals (Figure 1). The United Nations periodically publish global mortality for children. The relevance of Vitamin A deficiency mortality may be compared with other public health mortality factors (Figure 2). It is estimated that 1.3-1.9 million people, primarily children and mothers, died from vitamin A insufficiency in 2016, 26 years after the initial U.N. pledge to practically eliminate Vitamin A deficiency by the year 2000 (Figure 2). A global database of vitamin A deficiency (VAD) maintained by the World Health

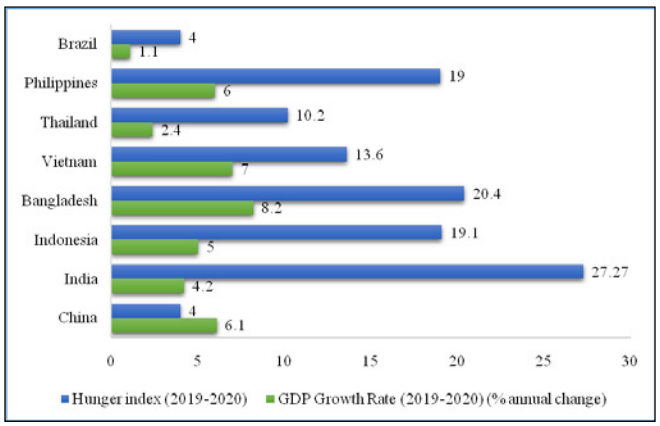

Figure 1: Hunger Index and GDP growth rate comparison of major rice-growing countries worldwide (Source: GHI, 2020)

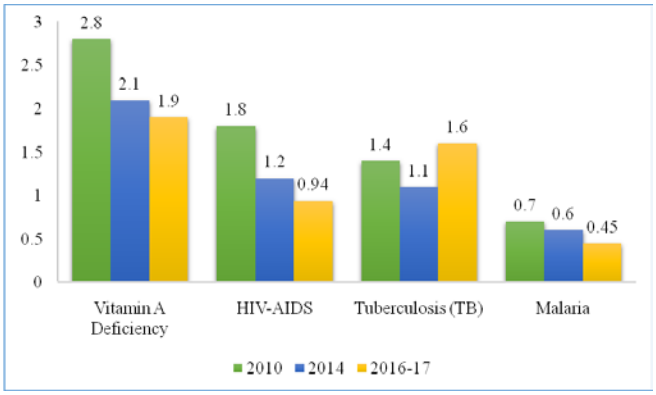

Figure 2: Global annual mortality (millions) by different health diseases (Dubock, 2019)

Organization shows that one out of every five preschool children in Bangladesh is low in this essential nutrient.

In the early 1990's, a research project was launched that released the technology underlying golden rice in 2000. To develop a source of vitamin A in the endosperm of rice, as an additional intervention for vitamin A insufficiency, was the goal from the beginning. Rockefeller Foundation was initially exposed to the golden rice project in 1999 when two professors, Ingo Potrykus and Peter Beyer, offered genetically modified rice. To fight vitamin A deficiency in developing nations, the Rockefeller Foundation funded the development of a biofortification strategy that would be sustainable. Prof. Ingo Potrykus and Prof. Peter Beyer sold their inventions to Syngenta in 2001 as part of a deal that required the business to support their humanitarian and philanthropic goals. While this was going on, the developers of the nutritional technique donated it to developing countries for their use. The IRRI was responsible for initiating the product development process. The rice was created by the Department of Agriculture-Philippine Rice Research Institute in cooperation with the International Rice Research Institute. Australia, the United States, and Canada have allowed golden rice as a food product. However, it has not been licensed for commercial production in those countries. The Philippines became the first country to authorize commercial production of genetically modified "golden rice" that scientists think would cure juvenile blindness and save lives in underdeveloped countries. It is also now being evaluated by regulators in Bangladesh (IRRI, 2021).

A Brief Timeline of Golden Rice

Transgenic Golden rice, in which endosperm-specific biosynthetic pathways of provitamin-A were introduced through genetic modification taking *psy* gene from maize (*Zea mays*) and *crtI* gene from a common soil bacteria, *Pantoea ananatis* (syn. *Erwinia uredovora*). Bangladeshi scientists have been involved in Golden rice research since 1999 when Swiss and German scientists developed transgenic rice. However, the process took off when IRRI plant biotechnologist Dr. Swapan K. Datta injected the beta carotene gene into BRRI dhan29 in 2002. Prof. Ingo Potrykus of the Swiss Federal Institute of Technology in Zurich and Prof. Peter Beyer of the University of Freiburg, Germany, were the first to apply genetic engineering to produce vitamin A in rice in 1999. In the first generation of Golden rice (GR1), genes from daffodils were used. However, in the second generation (GR2), a gene from maize was used since it produced a higher level of provitamin-A. IRRI opted to concentrate on one dubbed GR2R (scientifically termed "events"), which is created and later infused in Filipino and Bangladeshi rice varieties. In the Philippines and Bangladesh, after years of testing GR2R in labs and greenhouses, IRRI advised that a different line, GR2E, would be more effective. As a result, Golden rice (Figure 3) will only be accessible to the public once all required licences have been obtained in the Philippines and Bangladesh. Canada (March 16, 2018) and the U.S. Food and Drug Administration (February 22, 2018) rated golden rice as safe for consumption. For rice varieties listed in the National Seed Board (NSB) of Bangladesh, they must be

Figure 3: Golden rice is just another improved rice strain, yet it has a great potential to cover the micronutrient needs of rural, rice-based societies (Source: The Golden Rice Project, 2021)

biosafety approved (Dhaka, 2021). An application was made to the National Technical Committee on Crop Biotechnology (NTCBB) at the Ministry of Agriculture on November 26, 2017.

The NTCCB applied on December 4, 2017, to the National Committee on Biosafety at the Ministry of Environment. According to the Joint Department Circular No. 1 series of 2016, the Philippine biotechnology regulatory system consists of three regulatory review processes: direct use as food and feed or processing (FFP); field trials; and commercial propagation. GR2E golden rice was approved for direct use as food and feed, or processing, by the Department of Agriculture-Bureau of Plant Industry (DA-BPI) on December 18, 2019. Permission for a biosafety field trial was granted on May 20, 2019, by the DA-BPI. Field trials in DA-PhilRice stations in Munoz, Nueva Ecija, and San Mateo, Isabela were concluded in October of that year. In October, 2020, DA-PhilRice filed a commercial cultivation application for GR2E golden rice. From November 20, 2020, to January 19, 2021, a 60-days public feedback session was opened to the public. After the public comment period ended, DA-PhilRice responded to DA-queries BPI's in a letter of response on January 29, 2021 (IRRI, 2021).

Golden Rice under Evaluation in Other Countries

Australia, the USA and Canada have also studied the rice variety and given it favourable ratings but have not licensed it for commercial cultivation in those nations. Regulators in Bangladesh are also reviewing the plan. There has been a lot of opposition to genetically modified food plants from environmental groups. An activist group in the Philippines damaged a rice field in the past because it was feared to be a threat to human health, local biodiversity and farmers' livelihoods, according to a report. Critical environmentalists, including Greenpeace, are also unconvinced about golden rice's apparent benefits. Swiss-German scientists created golden rice in the 1990's, which has subsequently been sponsored by the Rockefeller Foundation in the U.S. and promoted by Monsanto, the notorious former U.S. agricultural behemoth now owned by Bayer.

Conclusion

Authorization for commercial production of genetically modified "golden rice" can cure infant blindness and save lives in developing countries. The Philippines is the first country to do so. Golden rice is enhanced with beta-carotene, a vitamin A precursor, so that it is more nutritionally dense. Golden rice will be deemed as safe as conventional rice and can be a significant milestone for nutritional security. There has been a lot of opposition to genetically modified food crops from environmentalists and activists in the Philippines also assaulted one trial site. Despite passing the final regulatory barrier, golden rice is still a long way off in appearing in food bowls. Australia, the United States and Canada have allowed the use of golden rice as a food product, but it has not been approved for commercial production. Regulators in Bangladesh are also reviewing the plan. It is also being reviewed by regulators in Bangladesh.

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