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"Golden rice –a saviour to tackle the vad"

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Abstract

Golden Rice is a genetically modified (GM) rice that contains beta carotene, a source of vitamin A, in the grain. It has a nearly 30-year development history and has an enlightening story of vision, imagination, technological ingenuity, and resilience. This GR project has the potential to help achieve six of the seventeen most critical Sustainable Development Goals by 2030. Golden Rice, once available, could be a protracted and cost-effective solution to the VAD that causes Nyctalopia and other immune-related illnesses.

Keywords: Golden rice, Beta carotene, Biofortification, VAD- Vitamin-A deficiency.

Introduction

According to the World Health Organization, half of the world's children with vitamin A deficiency (VAD) live in Southeast Asia and Sub-Saharan Africa (*Ghosh et al*. 2019). Vitamin A deficiency is estimated to affect 190 million preschool children and 19 million pregnant women worldwide, according to the World Health Organization (WHO). Up to 500,000 children go blind each year as a result of this disease, with half of them dying within a year of losing their sight. Vitamin A is essential for vision, growth, development, and maintaining a healthy immune system. Vitamin A insufficiency is caused by a lack of this nutrient in the diet, which weakens the immune system and increases one's sensitivity to infections and diseases, causes blindness, and can even lead to death if left untreated.

Rice is a staple food for almost three billion people around the world. It is consumed and farmed in over a hundred countries. It is a good source of carbohydrates, but it is deficient in several vital elements for health, such as carotenoids having provitamin A activity. In at least 26 nations in Asia, Africa, and Latin America, reliance on rice for nourishment adds to a severe public health problem of vitamin A malnutrition. Rice is widely produced and consumed in poor developing nations, so it seems natural that if it could be made to supply a source of vitamin A, millions of people who do not have reliable access to or cannot afford other sources of the vitamin could benefit. As a result, biofortified rice could be a long-term strategy for providing enough carotenoids (provitamin-A) to biofortify their diet and combat VAD. Biofortification is gaining traction as a possible crop-based solution to the problem of the mineral deficiency by increasing the density of bioavailable minerals and vitamins in food. Golden Rice, a genetically modified biofortified rice, has the potential to be a very good source of vitamin A, especially for individuals who rely on rice for their primary source of nutrition.

Golden rice

Some complicated properties, such as vitamin A, cannot be improved using traditional breeding approaches in staple grains like rice. Golden Rice was developed when scientists screened the rice germplasm for types that contained beta carotene in the grains but were unable to discover any. As a result, traditional breeding methods cannot be used in this situation. They recognize, however, that rice plants have the entire machinery for beta carotene synthesis, and that while this machinery is fully functioning in the leaves, sections of it are switched off in the grain. The process must be reactivated in order for beta carotene to accumulate in the grain. Two genes, a plant phytoene synthase (*psy*) and a bacterial phytoene desaturase (*crtI*) were added to Golden Rice to make this possible using genetic engineering technique.

Metabolic Engineering of β-carotene Pathway in Rice

The biosynthesis of 20-carbon beta carotene involves several processes, and plant transformation was still in its infancy when Potrykus and his team started the experiment in the late 1980s. It was a huge task to add new processes that often only comprised a single innovative reaction. In plants, four enzymatic steps are required to produce 40-carbon beta carotene from GGPP (a precursor to carotenoids). Phytoene synthase catalyzes a process that produces carotene phytoene from two GGPP. The phytoene molecule is then transformed into lycopene through two further processes. In the following phase, lycopene is cyclized to form beta carotene and other carotenoids.

In 1997, the first stage was completed: phytoene production in rice endosperm (Burkhardt *et al*. 1997) The daffodil (*Narcissus pseudonarcissus*) phytoene synthase gene was introduced into a rice variety, together with either constitutive or endosperm-specific promoters, and seeds were found to accumulate phytoene in the endosperm. However, many transformation events are necessary to complete the reaction from phytoene to the lycopene, which poses a challenge. However, researchers discovered a bacterial phytoene desaturase from the common soil bacterium *Erwinia uredovora* (now *Pantoea ananatis*) that performs all four essential modifications (Ye *et al*. 2000)

The complete beta carotene pathway was then introduced in one transformation event comprising two constructs, using Agrobacterium-mediated transformation. In the absence of a selective antibiotic marker, one plasmid carried phytoene synthase and phytoene desaturase. The phytoene synthase is controlled by an endosperm-specific promoter, while the phytoene desaturase is controlled by a constitutive promoter, and the coding sequences for both included transit peptides for plastid import, which were intended to localize lycopene synthesis to endosperm plastids that contain GGPP. In the same transformation vector, the second plasmid carried lycopene beta-cyclase, which catalyzes the last phase of beta carotene production and is controlled by the endosperm-specific rice glutelin promoter, as well as a selectable antibiotic (Hygromycin) resistance marker.

The expected golden color was observed in the endosperm of rice seed from transformants for the full complement of enzymes, and this is how rice with this yellow endosperm became known as Golden Rice.

The next important breakthrough came in 2005 when Syngenta scientists (Paine *et al*. 2005) employed a nonantibiotic selectable marker system to replace the original daffodil gene that manufactures phytoene synthase with a more efficient gene from maize (*Zea mays*). *Pantoea ananatis* had replaced *Erwinia uredovora* as the source of the bacterial phytoene desaturase. Golden rice-2 is a novel strain that has had the daffodil bottleneck gene deleted and replaced with the maize counterpart, resulting in a remarkable 20-fold increase in beta carotene. Critics of the original Golden Rice said that its pro-vitamin A content of 1.6 micrograms per gram of rice was insufficient to make the rice a viable option. The new strain, on the other hand, contains up to 37 micrograms of pro-vitamin A per gram. Tang *et al*. (2009) found that a cup (or roughly 150 g uncooked weight) of Golden Rice might provide 50 percent of the Recommended Daily Allowance of vitamin A for an adult on a daily basis.

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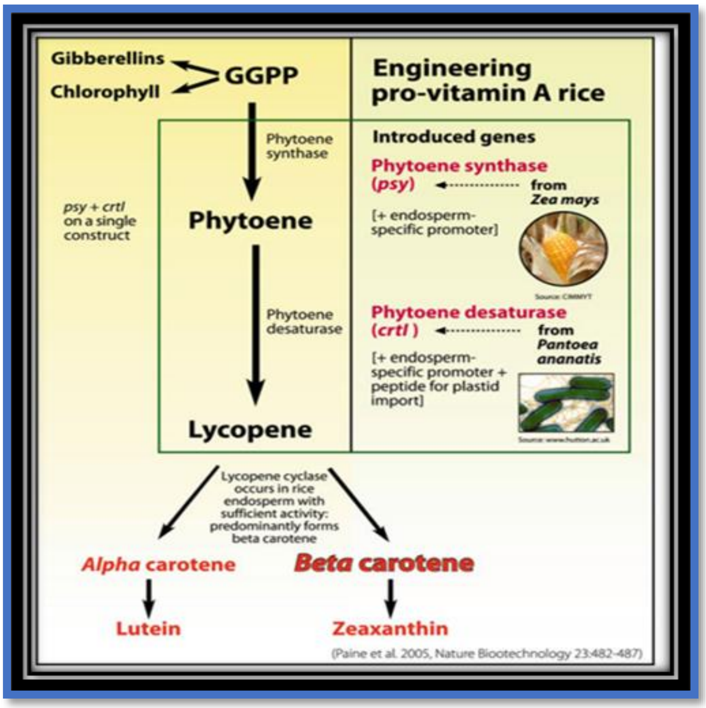
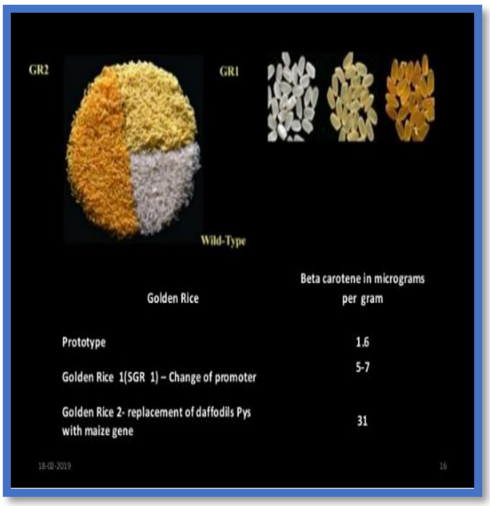
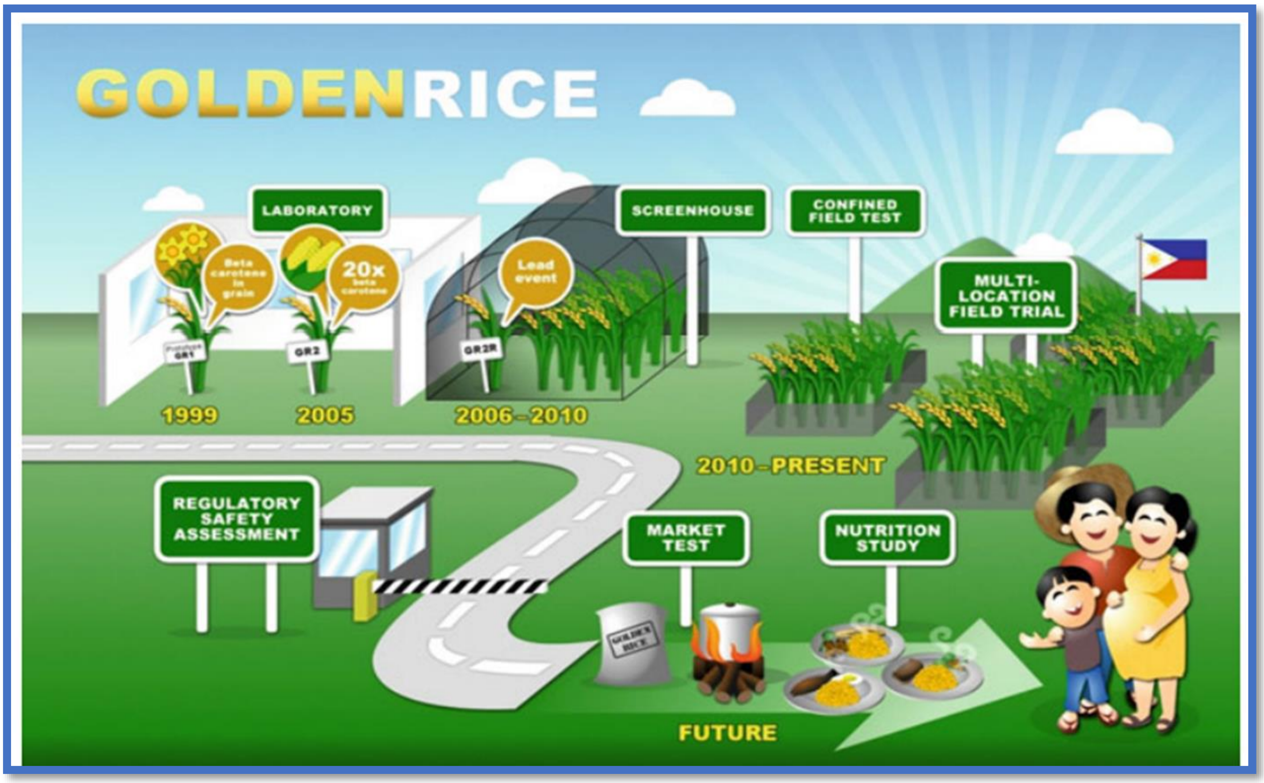




Conclusion

According to the Codex Alimentarius food safety recommendations, GM crops are evaluated using existing safety assessment methods. GM foods that are currently on the market have undergone safety testing and are unlikely to pose a health risk to humans. Many of us have been frustrated by the Golden Rice controversy. As Potrykus points out, it's sad that providing a free technology that may save so many children and pregnant women has taken so long. Each year, 2.5 million children are estimated to die from VAD since the invention of Golden Rice. Unfortunately, despite 20 years of research and development, GR is still not available for human consumption due to a variety of issues, the majority of which are regulatory and non-scientific in nature, such as anti-GM protests. International agencies and countries such as Bangladesh, Australia, and Canada have recently witnessed some good developments toward its availability. The Philippines is the first country to approve genetically modified Golden rice. Golden rice could be a new technique to aid people with vitamin A deficiency. There is a plan to improve Golden Rice even further by increasing the amount of additional micronutrients like iron and zinc, as well as the protein quality in the grains. Farmers could grow it in the same way they do rice today, and consumers could include it into their diets. It would be a pity to see its delivery further delayed by those opposing the adoption of a new technology at any cost especially when it is millions of very poor people who must shoulder those costs, not the opponents of Golden Rice.



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