AgriCos e-Newsletter
ISSN: 2582-7049
Volume: 02 Issue: 03 March 2021 Article No: 01

Golden Rice: A Genetically Modified (GM) Food

Surve V. D.[1] and Kamble K. P.[2]
[1]Associate Professor, [2]M.Sc. Student, Department of Post Harvest and Food Biotechnology, Vilasrao Deshmukh College of Agricultural Biotechnology, (VNMKV, Parbhani) Latur, (M.S.)

SUMMARY

The quantity of genetically modified (GM) foods is consistently increasing day by day as public concern grows. GM foods have been designed to be resistant to herbicides and high salinity; increase yields and increase nutritional value of food. Golden Rice is a GM crop intended to increase nutritional value i.e. vitamin A, a burning health problem in developing countries. Vitamin A deficiency can result in visual or ocular malfunctions such as night blindness and xerophthalmia and can reduce immune responsiveness, which can result in an increased incidence or severity of respiratory infections, gastrointestinal infections, and measles. 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. No evidence has found GM foods to be hazardous in terms of gene transfer, toxicity, or pathogenicity. However, GM foods have found to be allergenic. With appropriate regulation, GM foods have potential to have a positive impact on health.

INTRODUCTION

Ingo Potrykus and Peter Beyer in the 1990s were engineered normal rice to produced Golden Rice for human health improvement. Golden Rice has an engineered multi-gene biochemical pathway in its *genome*. This pathway produces beta-carotene, a molecule that becomes vitamin A, when metabolized by *humans*. Ingo Potrykus worked at the Swiss Federal Institute of Technology in Zurich, Switzerland, and Peter Beyer worked at *University of Freiburg*, in Freiburg, Germany. The US *Rockefeller Foundation* supported their collaboration. The scientists and their collaborators first succeeded in expressing beta-carotene in rice in 1999, and they published the results in 2000. Since then, scientists have improved Golden Rice through laboratory and field trials.

The research that led to golden rice was conducted with the goal of helping children who suffer from *vitamin A deficiency* (VAD). In 2005, 190 million children and 19 million pregnant women, in 122 countries, were estimated to be affected by VAD (*vitamin A deficiency*). VAD is responsible for 1–2 million deaths; 5, 00,000 cases of irreversible *blindness* and millions of cases of *xerophthalmia* annually. Children and pregnant women are at highest risk. Vitamin A is supplemented orally and by injection in areas where the diet is deficient in vitamin A. As of 1999, 43 countries had vitamin A supplementation programs for children under 5; in 10 of these countries, two high dose supplements are available per year, which, according to *UNICEF*, could effectively eliminate VAD. However, UNICEF and a number of *NGOs* involved in supplementation note more frequently, low-dose supplementation is preferable. Because many children in VAD affected countries rely on rice as a *staple food* and for *genetic modification* of rice to produce the vitamin A precursor, beta-carotene was seen as a simple

and less expensive alternative for supplementation. Golden Rice is named for its golden color, which is caused by beta-carotene. Normal rice, *Oryza sativa*, does not express beta-carotene in its endosperm. Beta-carotene is part of a class of molecules called carotenoids, one of hundreds that plants naturally produce, and it has a yellow-orange color. Carotenoids are essential nutrients for *humans*, because they are precursors to molecules needed in metabolism. The human body transforms beta-carotene, also known as pro-vitamin A, into vitamin A, which is necessary to produce retinal and retinoic acid. When people lack access to foods containing beta-carotene, because they eat mostly cereal crops such as rice, wheat, or sorghum, they are at risk of blindness and disease.

Vitamin A Deficiency

The intake of vitamin A provides humans with an important nutrient for vision, growth, reproduction, cellular differentiation and integrity of the immune system. Vitamin A deficiency can result in visual or ocular malfunctions such as night blindness and xerophthalmia and can reduce immune responsiveness, which can result in an increased incidence or severity of respiratory infections, gastrointestinal infections, and measles. Vitamin A can be obtained from food, either as preformed vitamin A in animal products (eg, eggs and dairy products) or as provitamin A carotenoids, mainly *beta*-carotene in plant products (eg, dark-green leafy vegetables and fruits). Rice, a food staple produces geranyl geranyl 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.

Efficacy of Carotenoids

Clinical and subclinical vitamin A deficiency is still a problem, affecting 250 million school children worldwide. To prevent clinical vitamin A deficiency in developing countries, chemically synthesized vitamin A supplements have been distributed periodically to deficient populations. This has been shown to be an efficient and generally safe strategy. However, supplementation programs with a periodic mass distribution have been difficult to sustain because of high distribution costs. Recently, food-based interventions to increase the availability of provitamin A–rich foods and their consumption have been suggested as a realistic and sustainable alternative to overcome vitamin A deficiency globally. However, the efficacy of carotenoid-rich foods in the prevention of vitamin A deficiency has been questioned in several recent studies, which reported little or no nutritional benefit of vitamin A from the increased consumption of dark-green or yellow vegetables. Recently, studies have shown that the equivalency of vegetable provitamin A carotenoids to vitamin A is in the range of 10–27 μg *all-trans* β-carotene to 1 μg retinol activity. These studies showed that food matrices greatly affect the bioavailability of vitamin A and carotenoids. The textbook example of *bio fortification* is Golden Rice, genetically engineered to contain high levels of the vitamin A precursor beta-carotene.

In recent years, scientists have introduced the biosynthetic pathway for provitamin A carotenoids into staple foods, including genetically engineered Golden Rice, which contains 1.6–35 μg β-carotene per gram of dry rice. Golden Rice-1, which was transformed with a construct containing a phytoene synthase gene from daffodil, contains 1.6 μg carotenoids (0.8 μg β-carotene) per gram of dry rice. Golden Rice-2 was transformed with a construct containing a phytoene synthase gene from maize and contains upto 35 μg β-carotene per gram of dry rice. Because the vitamin A equivalency of various foods and supplements varies from 2 μg β-carotene to 1 μg retinol (when provided as a β-carotene supplement in oil) to 27 μg β-carotene to 1 μg retinol (when provided as vegetable β-carotene), and this equivalency is matrix dependent, it is important to determine the vitamin A equivalency of β-carotene from Golden Rice. This information is critical for the purpose of designing informed, food-based nutritional strategies for rice-eating regions throughout the world where vitamin A deficiency is common. Because vitamin A is homeostatically regulated in the circulation of healthy subjects and it is impossible to distinguish the newly formed vitamin A from endogenous vitamin A, we chose intrinsic labeling of the provitamin A carotene as the optimal approach to determine its vitamin A equivalence. We produced intrinsically labeled Golden Rice, fed the rice to healthy volunteers, and used an isotope reference method to determine the conversion factor of Golden Rice β-carotene to vitamin A.

Advantages

- Combat malnutrition
- Reduce preventable blindness
- Improve our economy
- No apparent substantial environmental risk

Disadvantages

- Used as means for corruption
- Counter-productive commercialization
- No substantial health benefits

In addition to providing energy in the form of calories, our food also supplies us with essential vitamins and other nutrients to keep us healthy. Vitamin, or “micronutrient”, malnutrition is a substantial contributor to disease. To increase micronutrient consumption, many countries fortify their food with these vitamins. Another strategy to improve vitamin intake and prevent disease, especially in developing Nations, is the development of genetically modified organisms (GMOs). How do traditional fortification and GMOs compare, and are they equally effective and safe? Golden Rice, engineered to contain high levels of the vitamin A precursor beta-carotene, is a good case study to discuss these points and examine the science behind efforts to improve nutrition through genetic modification.

CONCLUSION

Initially, the justification for promoting adoption of Golden Rice as an additional intervention for vitamin A deficiency will be based on studies which have clearly demonstrated that a universal source of vitamin A can prevent 23–34% of global under five years’ child mortality, and up to 50% mortality prevention in the case of measles. It has also been known for a long time that vitamin A deficiency is the most important cause of irreversible childhood blindness. Sophisticated science has already confirmed that the beta-carotene in Golden Rice is very efficiently converted to circulating vitamin A in both adults and children: “Golden Rice may be as useful as a source of vitamin A as preformed vitamin A from vitamin A capsules, or eggs and milk”. Green vegetables are an important source of beta-carotene. But the conversion of beta-carotene in green leaves to vitamin A is very inefficient. So vitamin A deficiency is common even in populations where green vegetables are easily available and consumed. Additionally, lack of dietary variety, especially the lack of sufficient animal products in the diets of many who depend on rice, is responsible for vitamin A deficiency. Over to you, dear reader, to turn Golden Rice’s potential into reality.

REFERENCES

Adrian Dubock. (2014) Golden Rice: To Combat Vitamin A Deficiency for Public Health, *Golden Rice Humanitarian Board, Switzerland. Journal of Huazhong Agricultural University. DOI:http:dx.doi.org/10.5772/interhopen.84445.*

Adrian Dubock. (2014) The present status of Golden Rice, *Golden Rice Humanitarian Board, Switzerland. Journal of Huazhong Agricultural University.*

Bollinedi H, Krishnan SGK Prabhu KV, Singh NK, Mishra S, Khurana JP, Singh AK (2017) Molecular and Functional Characterization of GR2-R1 Event Based Backcross Derived Lines of Golden Rice in the Genetic Background of a Mega Rice Variety Swarna. PLoS One 12: e0169600, doi:10.1371/journal.pone.0169600.

Buu, M. (2003) Golden Rice: Genetically Modified to Reduce Vitamin A Deficiency, Benefits or Hazards? *Nutrition Bytes, 9[2]*. Retrieved from http://scholarship.org/uc/item/2h01f05c.

Dubock A (2017) An overview of agriculture, nutrition and fortification, supplementation and biofortification: Golden Rice as an example for enhancing micronutrient intake. Agriculture & Food Security, 6(1), 59.

Dubock A (2017) Golden Rice: instructions for use**.** Agriculture & Food Security, 6(1), 60.

Elliott M (2017) Agriculture and food security: fifth anniversary. *Agriculture & Food Security* **6**: 58, doi:10.1186/s40066-017-0137-1.