"GOLDEN RICE" GM VITAMIN-A RICE

Golden Rice is the name of a rice that has been genetically engineered (genetically modified or GM) to produce beta-carotene, which the body can convert into vitamin A. This beta-carotene gives the rice grains the yellowish colour that inspired its name.

Golden Rice is being developed by the International Rice Research Institute (IRRI), a research and educational organization based in the Philippines, along with various national partners in other countries.

Vitamin A Deficiency

IRRI and other proponents of Golden Rice claim that it will be an important intervention to address **vitamin A deficiency, or VAD**.

VAD is a serious problem in communities facing malnutrition and food insecurity. Its impacts are particularly severe for children and, if not dealt with, VAD can lead to blindness, and in severe cases, even death. The UN World Health Organization (WHO) estimates that 250 million preschool-age children in the world are deficient in vitamin A. Approximately 250,000 to 500,000 of these children become blind every year.[1]

VAD can be addressed through a combination of strategies, including dietary diversification, food fortification and supplementation. According to the WHO, supplementation programs around the world have averted approximately 1.25 million deaths since 1998,[2] and have reduced the risk of xerophthalmia[a] by approximately 90% and mortality by approximately 23-30% in young children.[3]

Regulatory Status of Golden Rice

There is no GM rice on the market anywhere in the world. Golden Rice is designed for use in the Philippines and Bangladesh but these countries have yet to approve it. Golden Rice has, however, been approved as safe for human consumption in four countries that will not be producing or consuming it: Canada, the US, Australia and New Zealand. No country has yet approved the rice for cultivation or assessed its potential in combatting VAD.

The **Philippines** Rice Research Institute (PhilRice) conducted field trials on Golden Rice in 2015 and in 2016. In February 2017, PhilRice and IRRI applied to the Philippines' Department of Agriculture-Bureau of Plant Industry for approval of Golden Rice for food and feed. This application is still pending.

a. Used by the WHO to denote the set of disorders resulting from VAD, and often used to measure the prevalence of VAD. See, for instance, WHO 2009.[3]

The **Bangladesh** Rice Research Institute conducted field trials on Golden Rice, and in 2017, applied for regulatory approval with the Ministries of Agriculture, and Forests and the Environment. This application is also pending. In February 2019, the Agriculture Minister of Bangladesh Dr. Abdur Razzak told media that he expected the pending approvals to be granted within two or three months, and said that Golden Rice would be available soon.[10]

However, IRRI also requested food safety clearance in countries where VAD is not a risk and where IRRI has no plans to release Golden Rice for production or consumption. In 2017 and 2018, Golden Rice was approved as safe for human consumption in **Canada, the US, and Australia and New Zealand**. These regulatory authorities **did not assess the ability of Golden Rice to address VAD**. IRRI was clear that the purpose of the requests was to determine safety and "not intended to address questions related to the efficacy of GR2E rice in helping combat VAD in at-risk populations."[11] Although Golden Rice is not intended for use in these countries and has not yet been approved for cultivation or use in any country, **IRRI says that it applied for these approvals because Golden Rice could enter these markets unintentionally via contaminated exports from rice-producing countries**.[12]

These approvals provide IRRI with the ability to communicate the safety of Golden Rice. According to the Director General of IRRI, Matthew Morell, "This is why we went to go through the regulation process in the US, Australia, Canada and New Zealand. These are some of the toughest regulatory agencies in the world and Golden Rice met the criteria set by them."[13] In an IRRI press release, Morell also said, "Each regulatory application that Golden Rice completes with national regulatory agencies takes us one step closer to bringing Golden Rice to the people who need it the most…. The rigorous safety standards observed by the US FDA and other agencies provide a model for decision-making in all countries wishing to reap the benefits of Golden Rice."[14] Farm leaders in the Philippines are concerned that IRRI will use these approvals to "put pressure on expediting commercialization in the targeted countries" and "bypass public opposition."[15]

BACKGROUND

Golden Rice was developed by two European scientists, Ingo Potrykus and Peter Beyer, who later licensed the technology to the major biotechnology and seed company Syngenta (at that time Zeneca) for commercial use. As per the agreement, the company could develop Golden Rice commercially but had to offer it free for "humanitarian use" (use in low-income, food-deficit countries, and for the use of farmers who earn $10,000 or less per year from farming). Syngenta negotiated licenses with other institutions and biotechnology companies, including Monsanto, to access the numerous patents and technologies needed to develop Golden Rice.[4,b] In 2004, Syngenta donated its research to the "Golden Rice Humanitarian Board" and stated it had no commercial interest in Golden Rice, though it retains the commercial rights.[5,6]

The ongoing efforts to develop and introduce Golden Rice are now managed by the Golden Rice Project. The Project is governed by the Golden Rice Humanitarian Board and involves various partner institutions across Asia through the Golden Rice Network.[7] The International Rice Research Institute (IRRI), in the Philippines, coordinates this network. Funding for the Golden Rice Project has been provided by the Rockefeller Foundation, Harvest Plus (which is funded by the Bill and Melinda Gates Foundation and the World Bank), the Swiss Development and Collaboration Agency, the U.S. Agency for International Development (USAID), the Syngenta Foundation, and a number of other national agencies and institutions.[8,9]

b 70 Intellectual Property Rights and Technical Property Rights, belonging to 32 different companies and universities, were used in the initial experiments.

GOLDEN RICE IN CANADA

The 2018 decision by Canadian government regulators (Health Canada) to assess and approve the safety of Golden Rice was not a "humanitarian gesture."[16] Health Canada was clear that "the efficacy of the GR2E rice in helping vitamin A deficiency in affected populations was not evaluated" and that "IRRI has indicated that this product is not intended to be sold in Canada."

So why did Health Canada assess the safety of Golden Rice for Canadian consumption? In its decision, Health Canada noted that "it may be possible that raw commodity or food products derived from GR2E rice may unintentionally enter Canada via imports from countries of production." In correspondence with CBAN, the department further stated that "Health Canada's science-based regulatory system for novel foods is internationally recognized and developers often choose to seek authorization in Canada as a first step in their regulatory plan even if they do not plan to sell the product in Canada."[17] Ultimately, "Health Canada is required by law (i.e., the Food and Drug Regulations) to assess all novel food applications when a notification is filed with the Department."[18]

"The Canadian government has just waded into a huge global controversy that should be left to Asian farmers and consumers to decide, not Canadian regulators. . . We need to first give the people and government of the Philippines time to assess and debate Golden Rice, before we weigh in."[19]

— Eric Chaurette, Inter Pares

Why Golden Rice is Not the Answer

IRRI says it wishes to introduce Golden Rice in countries such as Bangladesh and the Philippines, where there is a high risk of VAD and where rice consumption is high. However, **Golden Rice is not yet ready for farmers to grow or for people to eat**; its beta-carotene levels are not as high as in several other foods and degrade significantly during storage and cooking; and we still do not know whether it helps fight VAD. On its website, IRRI says that Golden Rice is in "advanced development."[20]

1. Golden Rice has low and variable levels of beta-carotene

The first version of Golden Rice produced only 1.6 micrograms (µg/g) of carotenoids per gram of rice.[21] This meant that a 2-year-old would need to eat 7 kilograms of cooked Golden Rice a day to meet their required daily intake of vitamin A, and a breastfeeding mother would need to eat 9 kilograms of cooked rice.[22]

In 2005, Syngenta announced "Golden Rice 2", claiming that they had solved this initial problem. The company's researchers estimated that a child could obtain half of their required vitamin A intake from eating 72g of dry Golden Rice 2 (GR2E) every day.[23] Now, IRRI says that Golden Rice has "achieved the target levels of beta-carotene expected to meet 30-50 percent of the estimated average requirement for vitamin A in the population sub-groups at highest risk of vitamin A deficiency (VAD)."[24]

However, in their 2016/2017 submissions for approval of Golden Rice to the US Food and Drug Administration (FDA), Food Standards Australia New Zealand, and Health Canada, IRRI reported that average beta-carotene levels for their GR2E Golden Rice[c] was 3.57 µg/g for milled rice.[d] At these levels, and considering the high rates of beta-carotene loss during cooking and storage (see page 4), as well as the highly variable conversion rate of beta-carotene to vitamin A (ranging from 6:1 to 21:1[25]), **an adult woman would need to eat several kilograms of Golden Rice a day – likely anywhere from 2 kilograms to over 20 kilograms, depending on how long the rice has been stored – in order to get her required daily amount of vitamin A**. Adult men, and pregnant and lactating women require even more vitamin A. On average, according to IRRI, people in the Philippines eat

c The genetically engineered GR2E event, backcrossed with a local variety.

d Beta-carotene levels ranged from 0.5 µg /g to 7.31 µg /g.

290g of rice a day, and people in Bangladesh eat 367g of rice a day. **In contrast, 100 g or half a cup of most green leafy vegetables is enough to meet the required daily amount of vitamin A for adults and children**.[26]

In a 2019 study on beta-carotene levels of Golden Rice, Bollenedi et al found that levels of the Golden Rice varieties they tested were slightly higher than those reported by IRRI above, and ranged from 7.13 µg/g to 22.81 µg/g when freshly harvested i.e. before storage and cooking.[27] All these levels show that **beta-carotene levels in Golden Rice varieties are still variable and low**. Even these higher beta-carotene levels are much lower than those of many vegetables. (See page 8).

The US FDA approved Golden Rice as safe to eat but said that "the concentration of B [beta] carotene in GR2E rice is too low to warrant a nutrient content claim" in the US.[28] The FDA's conclusion is based on the fact that Americans eat much less rice – approximately 45g/day – than the per capita daily consumption of rice in the Philipines or Bangladesh.[29] However, this statement from the FDA is a reminder that while Golden Rice has been approved as safe by the FDA and Health Canada, these approvals do not show that Golden Rice is in fact an effective solution for VAD or a useful source of vitamin A. As US public health and nutrition professor Marion Nestle calculates, to warrant a nutrient content claim in the US, one serving of Golden Rice would need to provide 1,080 micrograms of beta-carotene. One carrot, on average, provides about 4000 micrograms of beta-carotene.[30]

2. Golden Rice has not been adequately tested for bioavailability

We do not know whether Golden Rice improves the vitamin A status of people suffering from VAD. Vitamin A can only be absorbed by the body when it is consumed along with fat. Children and adults suffering from VAD, which is most commonly caused by malnutrition, often do not have access to fat in their diets.

Two studies have been conducted to assess the bioavailability of vitamin A in Golden Rice. The first study, published in 2009, fed Golden Rice to five American adults and concluded that beta-carotene in Golden Rice was effectively converted to vitamin A in humans.[31]

However, the study has been critiqued for having several inconsistencies, including the carotenoid levels in the rice used, the small number of test persons, and the high amount of variability in the results.[32,33] In addition, the study participants were given the rice along with butter, meat, nuts and vegetables, and none of them were suffering from any of the disorders commonly faced by malnourished children or adults. These results do not reflect the conditions of those suffering from VAD.[34]

The second study, in 2012 (by the same lead author), fed Golden Rice to 23 Chinese children between the ages of 6 and 8.[35] The study concluded that one serving of Golden Rice could provide half a child's recommended intake of vitamin A.[e] However, this study also fed children balanced meals with fats, demonstrating, as professors Dominic Glover and Glenn Stone point out, "only that Golden Rice worked in children who did not need it."[36]

In 2013, IRRI said that, "it has not yet been determined whether daily consumption of Golden Rice does improve the vitamin A status of people who are vitamin A deficient and could therefore reduce related conditions such as night blindness."[37] In 2019, their website says: "**After obtaining the necessary permits and approvals, an independent community nutrition study will be conducted to evaluate the efficacy of Golden Rice; in other words, whether or not it improves vitamin A status**. The nutrition study is necessary to determine the potential for Golden Rice to be used as a public health approach for reducing vitamin A deficiency."[38]

3. Beta-carotene in Golden Rice degrades rapidly during storage and cooking

A 2019 study by Indian scientists Bollinedi et al found that the beta-carotene in Golden Rice degrades over time.[39] This is especially important because rice is often stored for long periods before it is consumed. The scientists found that degradation rates were highest in polished rice (rice with the hull removed), followed by brown rice, and then paddy rice (unprocessed rice). They also found that degradation levels were lower in rice that was stored at cooler temperatures and not exposed to air (vacuum packed).

e This article was retracted in 2013 when the researchers of the study were found to have violated both U.S. federal regulations and Tufts University's ethics policies during this study. Among other violations, researchers fed Golden Rice to children in China without informing their parents that the rice their children were eating was genetically modified.[40]

However, in most rice eating countries, rice is eaten polished and is stored in unsealed containers (in the presence of air) at warm temperatures, often for long periods of time before it is consumed. **After six months of being stored in the presence of air at 25°C (a common temperature in most Asian countries), beta-carotene in Golden Rice degraded by 80-84%.**[41] The scientists f ound that the best way to preserve the beta-carotene in Golden Rice is to vacuum pack it as paddy rice – but paddy rice is rarely, if ever, eaten in Asia, and vacuum packing facilities are rare and expensive.[f] Commonly, rice has a shelf life of several years.

The scientists also found that cooking Golden Rice degraded the beta-carotene by 17-24%.

This means that if it is stored in common conditions in Asia, and cooked (as it always would be), Golden Rice could potentially lose all, or almost all, of its beta-carotene by the time it is eaten.

4. Golden Rice is not yet ready for farmers to grow

"…Over 14 years after IRRI began trying to adapt Golden Rice to the Philippines, the best varieties still exhibit a "yield drag" compared to isogenic seeds (i.e., lower productivity than seeds that are identical except for the Golden Rice trait) (Dubock 2014; Eisenstein 2014; IRRI 2014a). Contrary to claims that millions of children are dying worldwide because of Greenpeace's opposition to Golden Rice, the new strains simply are not ready and are not expected to be ready for at least several years."

— Glenn Stone and Dominic Glover, 2016[42]

Golden Rice has to be crossed with local varieties in order to be ready to cultivate. **Golden Rice researchers are still working to develop varieties that have yield, pest resistance and other qualities that make them suitable for farmers in Asia**.[43] IRRI also says that once they are granted regulatory approval, they will conduct "cooking and taste tests … to make sure that Golden Rice meets consumers' needs," and that "field tests and other evaluations" are yet to be done in partner countries to "help assess the safety of Golden Rice in the environment."[44]

A 2017 study by Indian researchers found that when the Golden Rice event GR2-R1 was crossed with the widely grown local variety Swarna, unintended yield loss and stunted growth resulted. The authors found that the Golden Rice DNA had disrupted genes in native rice, leading to the defects.[45] Molecular geneticist Dr. Michael Antoniou argued that this was due to negligence in the development process: "If [they] had conducted a proper molecular characterization of this GM event at the time it was generated, they would have identified the host gene disruption that led to the stunted and deformed growth of the rice plants. Then they could potentially have avoided this negative outcome at such a late stage in the development and release of golden rice. Now it's back to square one, with years of research work and millions of dollars wasted."[46] IRRI says that these lower yields were seen in the earlier event GR2R, and that they are now using "more promising events such as GR2E to advance the development of Golden Rice." [47]

IRRI and its partners have not yet completed the crucial step of developing a distribution program for Golden Rice. They say this will be done after Golden Rice is approved in targeted countries: "After Golden Rice receives all the required approvals for food, feed and cultivation and is found to be efficacious, a sustainable delivery program will ensure that Golden Rice is acceptable and accessible to those most in need."[48]

f Vacuum packed paddy rice stored at 25°C retained 54% of its beta-carotene level after 6 months. Air packed paddy rice retained 20% of its beta-carotene under the same conditions. Even at 4°C, rice stored in the presence of air lost 68-79% of its beta-carotene.

5. Golden Rice has not been adequately tested for safety

"In the light of the humanitarian claims made in the context of the Golden Rice project, it is surprising that this application is not based on a full set of data to establish high safety standards and evidence of the actual benefits."

— TestBiotech, 2018[49]

The German non-profit organization Testbiotech argues that, "it is self-evident that food products with no history of safe use must be subjected to the highest standards of risk assessment before the most vulnerable groups of the population are exposed to it."[50] Despite the fact that the target for Golden Rice is malnourished people, young children and lactating and pregnant women in particular, IRRI has not set a higher standard for data generation or transparency than that which currently exists for other GM foods.[51] On their website, IRRI says it uses a "weight of evidence" approach to conclude that the new proteins in Golden Rice are not "likely to be toxic or result in allergenic reactions in humans or animals."[52] IRRI has not made the science behind their claim of safety public, but it appears via documents released by Food Standards Australia New Zealand (FSANZ) through their assessment process. TestBiotech's evaluation of IRRI's application to FSANZ argues that the data is insufficient to reliably conclude safety.

One reason Testbiotech says there are insufficient grounds to conclude safety is the lack of toxicological studies. The application to FSANZ does not include any animal feeding studies (as would be required in any assessment by the European Union, for example). In fact, IRRI argues in their application that there is no justification for conducting such feeding studies to demonstrate safety.[53] IRRI's conclusion that Golden Rice is safe instead largely relies on comparing Golden Rice to other rice. For example, a study by IRRI scientists that compared the composition of GR2E and control rice varieties in the Philippines found that they were similar apart from beta-carotene levels.[54] This comparative approach, however, fails to consider a number of other unintended effects that could arise from the process of genetic engineering.[55] Moreover, the comparison that was made in IRRI's application used just one GR2 variety (one that showed lower levels of carotenoids than the projected goal) and could therefore mean that the conclusions are unreliable. This is especially the case because the expression of transgenes in Golden Rice has been shown to be influenced by both the variety of rice used as well as by the environment.[56]

Proponents and developers of the genetically engineered rice have not displayed caution in relation to safety questions in the past. When facing criticism about the 2012 study (see footnote e) that tested Golden Rice on Chinese children, Adrian Dubock, the manager of the Golden Rice Project and a former Syngenta employee, said, "Golden Rice contains the food colours found everywhere in coloured, natural foods and the environment. There is no possible way the trials could do any harm to the participants."[57]

6. Golden Rice poses environmental risks

Proponents argue that since rice is largely self-pollinating, and its pollen does not remain viable for long, Golden Rice will not contaminate non-GM rice varieties. However, studies in China have shown that gene flow can in fact occur from GM rice to wild and weedy rice.[58,59] This contamination could affect both wild rice populations and the cultivated rice seed supply, and it would be very difficult – or impossible – to reverse such contamination.

GM rice could also contaminate the rice supply after harvest, by mixing with non-GM rice. In fact, IRRI explicitly requested approvals in the US, Canada, and Australia and New Zealand based on the possibility of Golden Rice contaminating rice exports.[60] The environmental, economic and social impacts of any contamination would be particularly serious in Asia, which is the centre of origin for rice and where rice is a staple food in daily diets and important export crop.

7. Golden Rice is expensive and unnecessary

While exact numbers are unknown, millions, or perhaps billions, of dollars have been spent on developing Golden Rice, and on promoting it. In fact, by 2001, $100-million dollars had already been spent on developing the rice, and another $50-million on ads for it.[61] A large amount of money was already being spent on promoting Golden Rice, despite the fact that it was not ready. **Almost 20 years later, it is still not ready, or an effective solution to VAD**. The amount that has been spent on developing Golden

Rice has grown significantly since, as more research funds have been injected into the project.[62] These important resources could have gone towards developing and expanding existing and proven approaches to addressing VAD, and implementing them for the communities that urgently need them.

On their website, IRRI says that "Golden Rice is intended to be used in combination with existing approaches to overcome VAD, including eating foods that are naturally high in vitamin A or beta-carotene, eating foods fortified with vitamin A, taking vitamin A supplements, and optimal breastfeeding practices." [63] However, these other solutions are proven, are already being used, and are much less costly to implement.

As professors Glenn Stone and Dominic Glover summarize, "IRRI itself acknowledges that VAD is being effectively reduced without Golden Rice, but holds that the reductions may be due in part to nutrition and breastfeeding programs that may have less impact in "difficult to reach" areas... Thus, as Golden Rice becomes embedded, it shrinks from a sure solution, to a pervasive public health crisis of the developing world, to a possible dietary supplement in certain, unnamed, difficult-to-reach spots in the Philippines."[64]

Solutions that support people to grow vitamin-A rich foods, on small-scale farms and home gardens, are accessible, affordable, provide multiple benefits, and can be community-owned and managed. Perhaps most importantly, along with effectively countering VAD, such strategies also help address **the root problem of poverty and hunger**.

The Real Problem

Golden Rice does not address the real problem. **Vitamin A deficiency is not an isolated issue: it is a symptom of hunger and malnutrition, which are caused by poverty and inequality**. These are deep-rooted and complex socio-economic problems.

Because VAD is a symptom of inadequate nutrition, children who suffer from VAD are often also lacking in other micronutrients.[65] Furthermore, the body effectively absorbs vitamin A only when it has sufficient levels of other nutrients, such as zinc and vitamin E, as well as fat and protein.[66,67] In this context, **strategies that target more than one nutrient deficiency, and go deeper to target the root cause of malnutrition and hunger, are effective in the longer term**.

The Real Solution

The complex socio-economic problems of hunger and poverty call for long-term, sustainable and broad-based solutions that create food security. **Ensuring that people have access to a diverse and healthy diet addresses a whole host of micronutrient deficiencies and health problems, while also being responsive to social and economic problems**. The significant resources being spent on developing and marketing Golden Rice would be better used to support these goals.

VAD, in particular, can be addressed with several existing and proven measures, including immediate intervention strategies that lower rates of VAD, as well as lasting and transformative solutions that reduce malnutrition in the long term. The WHO and the United Nations Standing Committee on Nutrition (UNSCN) both recommend a multi-tiered and integrated approach to combatting VAD. This includes supplementation and breastfeeding, which are effective in the short term, as well as food fortification, which can help maintain adequate nutrient levels, and **diet diversification, which is a lasting approach to building food security**.

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Immediate Interventions: Supplementation and Food Fortification

There are a number of examples of highly successful intervention programs from around the world, designed to suit the needs of the communities they are targeting. Several countries have had fast success with **Vitamin A supplementation** programs. Supplementation involves administering 1 or 2 doses of high-dose vitamin A capsules to children every year. These capsules are effective, easy to administer, and a single dose costs just a couple of cents.[69] According to the WHO, "For deficient children, the periodic supply of high-dose vitamin A in swift, simple, low-cost, high-benefit interventions has [...] produced remarkable results, reducing mortality by 23% overall."[70] In 2014, 69% of targeted children in priority countries were protected with two doses of supplementation.[71]

The Philippines introduced a vitamin A supplementation program in 1999. The supplementation was combined with food fortification, nutrition education programs and encouraging home and school food production.[72] VAD in preschool children was reduced from 40% in 2003 to 15% in 2008.[73] The WHO considers 15% the level at or below which deficiency is no longer considered a public health problem.[74] Levels of VAD in the Philippines are now below 5%.[75]

Food fortification can play a complementary role in addressing VAD. While supplementation can reduce VAD levels rapidly and effectively in the short-term, food fortification can help maintain these improvements by providing regular intake of vitamin A.[76] Along with vitamin A, micronutrients such as iron, iodine, zinc and other vitamins are commonly added to flours, cereals, oils, salt and sugar. Several countries in Latin America, including Guatemala, El Salvador and Cuba, fortify sugar supplies with vitamin A and have reduced levels of VAD.[77] In some European countries, fortified foods like margarine contribute approximately 20% of the required vitamin A intake.[78]

Programs that support the use of crops that naturally have high levels of vitamin A have also been beneficial. Initiatives encouraging families to grow orange-flesh sweet potatoes instead of the more common white-flesh ones have reduced VAD in some African countries.[79] Eating just one small orange-fleshed sweet potato a day provides enough vitamin A for a young child.

The Solution: Access to a healthy and diverse diet

Access to a healthy and diverse diet is the solution to vitamin A deficiency.

Golden Rice offers significantly less beta-carotene than a number of common vegetables, such as sweet potato, carrots, spinach and other locally available foods. Orange-fleshed sweet potatoes, for instance, have up to 60 times as much beta-carotene as Golden Rice. Carrots have 23 times and spinach 17 times as much beta-carotene as Golden Rice.[80] (see chart).

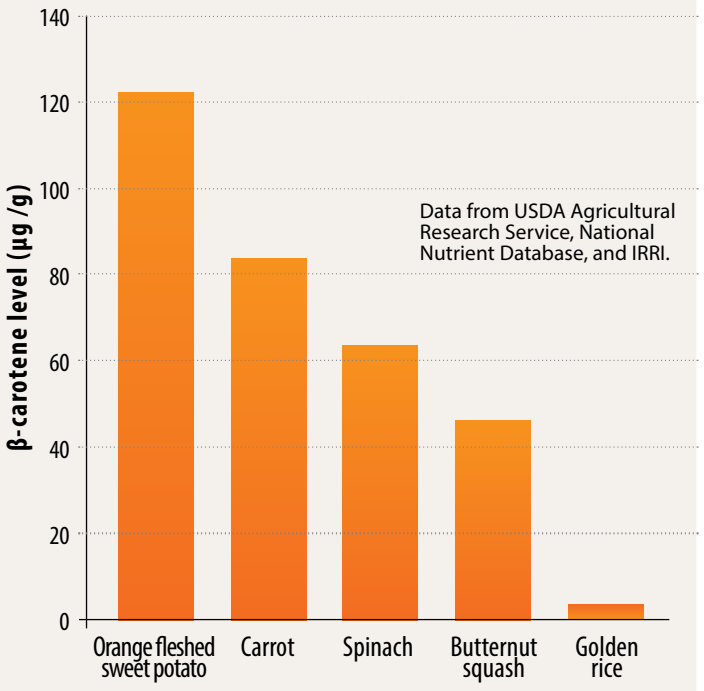
The Golden Rice Project itself states that "the best way to avoid micronutrient deficiencies is by way of a varied diet, rich in vegetables, fruits and animal products."[81] This is true. For instance, a child can, on average, get their daily requirement of vitamin A from:

- 93 grams (less than half a cup) of spinach
- 42 gms (less than a quarter cup) of amaranth leaves
- 155 gms (approximately a cup) of mango
- 275 g (less than two cups) of cooked carrot[82]

or for that matter, even very small quantities of several crops that are native to Asia and Africa, such as jute, mustard, drumstick, pumpkin, yam and sweet potatoes.[83,84,85]

Breastfeeding is an important approach to reducing VAD in infants. According to the WHO, "since breast milk is a natural source of vitamin A, promoting breastfeeding is the best way to protect babies from VAD."[86]

Beta-carotene values of common foods and Golden Rice



In addition, **for the body to absorb beta-carotene, it must be receiving fat and protein.[87] Few children who are severely malnourished are getting either. This means that a more long-term and effective solution would be to commit resources to support diverse crop production, home gardening, nutrition education, and to strengthen sustainable agricultural systems and infrastructure**. Such solutions help build food security,

and are significantly more cost-effective than the multi-million-dollar Golden Rice project. Homestead gardens, for instance, have been found to be very successful in reducing night blindness in children, at a cost of approximately $8 per garden.[88] In addition, these approaches are sustainable in the long-term, address multiple nutrient deficiencies simultaneously, strengthen food security, and can help supplement family sources of income. The UNSCN recommends **supporting local, small-scale agriculture** as a promising and effective long-term approach to maintain agricultural diversity, improve nutrition levels and minimize the ecological impact of agriculture.[89]

Bangladesh's Homestead Food Production Program, implemented by several organizations and supported by Helen Keller International, is one example of a highly successful approach to eradicating VAD. The program encourages and supports families to set up home gardens and small-scale animal husbandry projects, most often tended by women. It has been effective in reducing VAD and other micronutrient deficiencies, while also empowering women and creating approximately 60,000 rural jobs.[90] Families who had home gardens were found to be consuming significantly higher levels of vegetables and eggs, and had an increased intake of vitamin A.[91] Combined with nutrition education, this approach has increased vitamin A consumption, as well as broader food security and empowerment of women, for millions of people.[92,93]

These examples point to a number of effective strategies to reduce VAD. Such programs are affordable and effective and, taken together, present an integrated approach for addressing the short and long term health impacts of micronutrient deficiencies. There is, however, a need to continue to strengthen these programs, and expand them to have greater coverage. Hunger and malnutrition remain significant problems, and micronutrient deficiencies affect a large number of children globally, especially in Africa and South Central Asia.

The millions of dollars that have been poured into developing and marketing Golden Rice over the past 20 years could have been much more effectively and immediately used to expand less costly, proven, and long-lasting solutions with multiple benefits.

Other Resources:

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For more information and details: **www.cban.ca/goldenrice**

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The Canadian Biotechnology Action Network (CBAN) brings together 16 organizations to research, monitor and raise awareness about issues relating to genetic engineering in food and farming. CBAN members include farmer associations, environmental and social justice organizations, and regional coalitions of grassroots groups. CBAN is a project on Tides Canada's shared platform. **www.cban.ca**