Golden Rice: An Intimate Debate Case

Annie Prud'homme Généreux,
Curriculum Coordinator for Life Sciences, Quest University Canada

Introduction

A lack of vitamin A is one of the most common nutritional deficiencies in developing countries. Vitamin A deficiency (VAD) can negatively affect growth and development, cause blindness, interfere with the growth of epithelial cells, and suppress the immune system (Sommer, 1997). Vitamin A can be synthesized from the β-carotene found in green leafy vegetables and yellow fruits or vegetables, and it can be obtained from certain animal products (liver, egg yolk, etc).

Rice is a staple food in many developing regions of the world. Unfortunately, it contains no β-carotene in its milled grain, and is therefore not a source of vitamin A. Rice can be genetically engineered to boost its nutritional content. It is possible to transfer the genes for β-carotene from a plant that produces it into rice DNA (Ye et al., 2000). The resulting rice, dubbed "Golden Rice" (GR) because of its yellowish tinge, can provide a key nutrient in the diet of those who eat it.

In 1999 when Golden Rice was first created, it was hailed as the solution to world malnutrition, at the vanguard of a food revolution. Nearly 10 years later, it is still only a promise. Why have developing nations been slow to adopt this technology? Is it a worthwhile endeavor? We will hold an intimate debate on the merits of Golden Rice to tease out the issues surrounding its use in developing countries.

Procedures

Step 1 – Get Informed on One Position (10 min)
Form teams of 4 students. Each team will be given a list of facts on golden rice. Some teams will be given facts that support a Pro position (Golden Rice is a good strategy for alleviating vitamin A deficiency in developing nations), and some teams will be given facts that support the Con position (Golden Rice is not an effective means of addressing the vitamin A deficiency in developing countries). You will have 10 minutes to review this information and organize your arguments. You may take notes. However, you will not be allowed to bring the printed fact sheet with you on the next step.

Step 2 – Convince Others of Your Position (2 × 5 min)
Split your team into 2 teams consisting of 2 people. Each mini-team should now meet with a mini-team from a group that had the opposite position (i.e., a Pro mini-team meets a Con mini-team). Each mini-team has 5 minutes to convince the opposite team of its position. Members of the presenting team may only use their notes, not the hand-out. Members of the "audience team" should take notes, as they will be asked to argue for the other side in the next step. Each person is only allowed to ask ONE question for clarification.

Step 3 – Convince Others of the Opposite Position (2 × 5 min)
Find a mini-team that had the opposite position to your starting position (i.e., if you were initially Con, look for a second Pro mini-team). The procedure is the same as in Step 2 above, except that you must now argue the other position (not your initial position).

Step 4 – Decision (10 min)
Rejoin your original team. Decide whether your group is for or against the development and use of Golden Rice in developing nations. Be prepared to summarize the reasons leading to your decision to the whole class.

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Pro Golden Rice Handout

- "VAD is the primary cause of childhood blindness worldwide and is now recognized as a major contributing factor in an estimated 1 million–3 million child deaths each year" (WHO, 1995, 2008; Al-Babili & Beyer, 2005; Mayer, 2007).
- Rice is a staple food in many developing regions. For example, in Bangladesh nearly 80% of calorie intake comes from rice (Bois, 2000; Mayer, 2007).
- "The most recent calculations for India show that, in a scenario of widespread adoption and full government support, GR could reduce the number of VAD children by more than half" (Mayer, 2007, see also Al-Babili & Beyer, 2005).
- The complete daily recommended dosage of vitamin A is not required to bring about health improvements (Enserink, 2008).
- β-carotene (consumed from vegetable sources) must be absorbed in the gut and transformed to vitamin A in the body. This process is somewhat inefficient. In calculating the dosage of vitamin A resulting from the consumption of GR, it has sometimes been "assumed that the uptake of β-carotene by the human gut and its conversion into vitamin A were quite inefficient, resulting in one vitamin molecule for every twelve molecule of β-carotene […] A soon-to-be-published study among healthy volunteers who ate GR, led by Robert Russell of Tufts University in Boston, suggests that it's more like one [vitamin A molecule created] for every three or four [β-carotene molecules consumed]" (Enserink, 2008).
- A new version of GR has been created. "Dubbed GR2, [this strain] produces up to 23 times more β-carotene in its seed [than the original Golden Rice, GR1]" (Enserink, 2008). Even using the 12:1 conversion factor, "72g of GR2 polished rice would provide 50% of the [recommended dietary allowances] for children" (Paine, 2005).
- The patent laws governing the use of GR fall under a Humanitarian License. Accordingly, farmers earning less than USD $10,000 per year may use GR free of charge. Farmers may also keep seeds from each harvest and sow them the following season (Potrykus, 2001; Al-Babili & Beyer, 2005; Enserink, 2008).
- The GR trait can be introduced into any local variety making it easy to preserve the cultivation of traditional varieties with added value (Mayer, 2005; Enserink, 2008). This will adapt Golden Rice to local growth conditions, and will prevent the spread of monocultures.
- "Conventional breeders can bombard plant cells with chemicals and radiation to create useful mutants without having to check how it affects their DNA; a GM insertion must be "clean"—that is the extra genes must sit neatly in a row without disturbing other genes" (Enserink, 2008).
- Some populations may have limited-access to vitamin A-rich foods. Many families in poor countries cannot afford to buy a varied diet. Many of the fruits and vegetables that could provide vitamin A do not grow in the area, or are perishable, or they are only available seasonally. Meat products may also be difficult to obtain (Al-Babili & Beyer, 2005; Mayer, 2005; Enserink, 2008).
- "Experience with vitamin A supplementation [and fortification] programs revealed that coverage achieved over the last decade in 103 priority countries has stagnated at 58%, with high year-to-year fluctuation." (Mayer, 2005, 2007; UNICEF, 2007). In addition, supplementation programs rely

on on-going funding to purchase and distribute the vitamin A. Golden Rice would only need to be distributed to farmers once, as the crops produced annually by these farmers would provide the required nutrients thereafter. It is a more sustainable strategy (Al-Babili & Beyer, 2005).

- "Excess dietary β-carotene [provided in Golden Rice], in contrast to excess vitamin A [provided in supplementation programs], has no harmful effects" (Guerinot, 2000).
- "A calculation by the World Bank predicts that […] adoption of GR could signify a windfall of $15 billion/year for Southeast Asia" (Pohl Nielsen & Anderson, 2003; Anderson et al., 2004).
- "Provitamin A [β-carotene] is normally produced in the green tissues of every plant and converted to vitamin A in the human body. Nobody has been able to come up with a scenario whereby the provitamin A-enriched grains of GR could pose a menace to the environment or to human health" (Potrykus, 2001; Mayer, 2005).
- It was not possible to develop Golden Rice using traditional breeding methods (Potrykus, 2001; Al-Babili & Beyer, 2005).
- The GR project was funded by not-for-profit and public sources: the philanthropic Rockefeller Foundation, the Swiss Federal Institute of Technology, the European Community Biotech Program and the Swiss Federal Office for Education and Science (Guerinot, 2000; Potrykus, 2001).
- Part of the public opposition to GMO stems from ignorance about biotechnology. "The 2005 Eurobarometer poll indicated that almost 25% of Europeans believe that a person's genes can be modified by eating GM fruit, while 59% of Europeans do not believe tomatoes contain DNA" (Baggott, 2006). Both of these beliefs are wrong.
- "Extensive evidence from widespread production and consumption of GM plants—more than 90 million hectares planted in 2005—indicates that no specific harm emanates from transgenic crops, while clear life-threatening conditions arise from the lack of micronutrients" (Mayer, 2005).
- "GR is self-fertilizing, rice pollen grains are only viable for three to five minutes, and even if transgenic pollen made it to a wild rice plant, the genes it carried would not crowd out wild rice because its beefed-up β-carotene genes confer no leg up when it comes to natural selection" (Baggott, 2006).
- Rural Philippine rice growers were asked if they would grow a GMO rice strain that had a different color. Thirty out of 32 interviewed farmers indicated that they would, as long as this rice strain produced as high a yield as their current strain, and that it was safe to eat (Chong, 2003).

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Con Golden Rice Handout

- The gut does not absorb β-carotene efficiently. According to dietary reference guides, only one molecule of β-carotene is absorbed for every 12 consumed. If this is true in Golden Rice, it means that a woman would need to consume 5.25 kg of uncooked Golden Rice (GR1) every day to meet daily vitamin A requirements (U.S. NASIM, 2006).
- Golden Rice 2 (GR2) produces 23× more β-carotene than GR1 and contains sufficient quantities of β-carotene to meet the nutritional requirements for a person. However, no study has yet investigated how this chemical will fare through the steps of rice preparation (milling, storing, cooking, etc.) (Krawinkel, 2007; Glenn, 2008; Enserink, 2008). β-carotene may be degraded by these steps.
- "Although a GMO approach is straightforward in theory, past experience has shown that there is often a trade-off in cereals, where enhanced protein levels can lead to diminished yields or to alterations in other nutritional or grain quality components" (Sun et al., 2003).
- Dietary fats and zinc are needed for the absorption of β-carotene and synthesis of vitamin A. Since these nutrients are limited in rice-eating countries, the absorption of β-carotene from Golden Rice will probably be less than optimal (Jayarajan et al., 1980; WHO, 1998; Dawe et al., 2002; Grain, 2008).
- "Cultivated rice could outcross with its wild and weedy relatives and thus the Golden Rice could possibly lead to genetic contamination of wild rice; this is not reversible […] and brings with it economic and environmental problems" (Liu, 2006).
- It may be difficult to cross Golden Rice with local varieties of rice and preserve the β-carotene trait since many genes are necessary for its production and could be lost during the crossing.
- Cultivation of Golden Rice in many fields across the world will reduce the genetic diversity of rice. Genetic diversity is our insurance against environmental stressors such as parasites and temperature variations. If these stressors occur and wipe out a specific strain of rice, other strains might prove resistant. However, if all the rice in the world is the same, all rice could be wiped out by the stressor.
- Transferring genes between species is undesirable and can lead to allergic reactions. There is a report of people being allergic to GM soybean into which Brazilian nut DNA had been incorporated (Nordlee et al., 1996). Similarly, the gene for a protein capable of killing a common pest of the bean was inserted into pea DNA. The chemical structure of this protein was subtly altered in the new organism and found to cause allergic reactions in mice (Prescott et al., 2005). Since genes from several organisms were inserted into Golden Rice, people with pre-existing allergies to these organisms may also be allergic to Golden Rice (and would eat Golden Rice without knowing the dangers).
- The vitamin A gene in Golden Rice comes from daffodil (Ye et al., 2000). However, rice already makes vitamin A in its husk (the husk is not digestible and is removed before consumption). It should be possible to force the rice vitamin A gene to be expressed in the grain. This would prevent the incorporation of a transgene from another organism.
- Adding the β-carotene genes to local rice varieties will change the color of the rice. "This can give rise to objections in some regions […] It is possible to change people's preferences for color, but it is an arduous process requiring close contact with customers and education measures" (Mayer, 2007).
- As a consequence of choosing a GMO approach to address vitamin A deficiency, "regulatory approval must be sought on a country-by-country basis and will involve the completion of regulatory dossiers

as required by national legislation" (Mayer, 2007). "Present regulatory regimes have made the approval process for transgenic crops prohibitively expensive. Compliance costs in a country like India may amount to $5 million" (Mayer, 2007; see also Pohl Nielsen & Anderson, 2003).

- GMO opponents see Golden Rice as a public relations or marketing ploy to ease public concerns about GMOs, secure positive media coverage, and render this technology more acceptable. It is seen as "a 'Trojan horse' that may open the route for other GMO applications" (Potrykus, 2001).
- Golden Rice might interfere with existing vitamin A supplementation and fortification programs and campaigns (Krawinkel, 2007).
- "The Green Revolution of the 1960s and 70s replaced diverse cropping systems with monocultures of new wheat and rice varieties […] Monoculture in the fields predictably led to less diverse diets. In India, household consumption of vegetables has decreased 12% over the past two decades. In Thailand, 80% of caloric intake now comes from rice, up from less than 50% before the Green Revolution. An impoverished diet that consists of little else but rice (golden or not) will never provide a solution to world hunger or malnutrition" (Legislative Assembly for the Australian Capital Territory, 2004; see also Baggott, 2006).
- The biotechnology firm Syngenta owns the rights to Golden Rice for commercialization.
- "[While the GR1 rice strain is a product of publicly-funded research], the [GR2] rice strain is entirely a product of Syngenta's corporate R&D funding" ("Reburnishing Golden Rice," 2005).
- Many countries are opposed to the use of GM crops on their land. "EU market access is very important to developing countries. Some like Zimbabwe have banned GM foods (including GM food aid and Golden Rice) due to the fear of being shut out of European markets (Baggott, 2006).
- The humanitarian license governing the use of Golden Rice allows farmers with income less than USD$10,000 to have free access to the grain. However, it only permits these farmers to engage in national (and not international) trade of this rice (Al-Babili & Beyer, 2005). This, and international trade agreements on GMOs, will limit the income potential of the farmers by barring access to certain markets.
- "A 2005 Eurobarometer poll showed that 54% of European consumers find GM food dangerous" (Baggott, 2006; see also Pohl Nielsen & Anderson, 2003).

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