The John M. Rezendes Ethics Essay Competition

GOLDEN RICE: A GENETICALLY MODIFIED SOLUTION TO GLOBAL MALNUTRITION AND VITAMIN-A DEFICIENCY THROUGH THE BIOSYNTHESIZING OF BETA-CAROTENE

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There is a worldwide problem of malnutrition and vitamin-A deficiency in developing countries. Rice is the basic staple crop for half of mankind, yet rice is lacking micronutrients, such as beta-carotene (pro-vitamin A), which makes this predominant food source the main cause for vitamin A deficiency (Potrykus, 2008). As the world's most important staple crop, South Asia and Southeast Asia grow and consume ninety percent of the world's rice (Virk, 2008), meaning that these parts of the world are at the highest risk for vitamin A deficiency due to greater consumption. As a supplement for the resolution of vitamin-A deficiency, Ingo Potrykus and Peter Beyer developed Golden Rice in 1999 (Golden Rice Humanitarian Board, 2005-2011), a biofortified rice that was only possible through genetic engineering (Potrykus, 2010). Golden Rice is bioengineered to express beta-carotene in rice endosperm, which should greatly reduce vitamin-A deficiency and malnutrition in developing countries where rice is the main staple crop (Dubock, 2009). Reducing mortality and morbidity due to vitamin A deficiency in poor, developing countries is the sole purpose of Golden Rice. This makes Golden Rice unique, given that this genetically modified crop it is neither for the profit of multinational or private companies, nor for wealthy consumers in industrial societies (Dubock, 2008). Public support for technology development, release, and distribution will determine the ultimate success of Golden Rice (Qaim, 2008). Unfortunately, lacking support for technology has prevented the release and distribution of Golden Rice thus far. So, the world is faced with an ethical dilemma: continue to allow unqualified regulations without any real justification for taking extreme precautions and overwhelming resistance to new biotechnology, or continue to allow millions of people to die when there is a known and cost-effective solution, where responsibility should be assumed for the malnutrition and vitamin-A deficiency of children worldwide.

Every day there are approximately 24,000 people that die due to micronutrient deficiency (Potrykus, 2008). In particular, vitamin A deficiency causes 500,000 people to become blind annually, 50 percent of whom die within a year of becoming blind (Golden Rice Humanitarian Board, 2005-2011). Vitamin A deficiency is most prevalent among the poor who depend on rice for their predominant food source, since indigenous forms of rice lack provitamin A. Conventional breeding is not always an option. For this reason, biofortification offers a cost-effective way to combat micronutrient deficiencies. This is because Golden Rice is tailored for local consumption, where there is only a one-time investment for distributing seeds to farmers.

Genetic modification can offer potential for meaningful trait variation in Golden Rice to fight vitamin A deficiency (Beyer, 2008). In the endosperm of the rice, which is the edible part of the rice, there is an absence of provitamin A (International Rice Research Institute, 2009). So, biofortification of food with missing substances allows plants to produce the necessary micronutrients where conventional breeding is impossible. Since lacking variation in traits makes conventional breeding impossible for rice, Golden Rice had to be genetically engineered in order for beta-carotene to be present (Beyer, 2008). This is because beta-carotene is not present in the indigenous rice endosperm, and therefore recombinant DNA modification is used as an alternative to classical breeding (Beyer, 2008).

There are several strains of Golden Rice that allow for the adjustment of the beta-carotene level based on the needs of a given society (Potrykus, 2008). Evaluation of beta-carotene levels are necessary in Golden Rice for the benefit of public health in each individual community in order to determine which strain of Golden Rice will be the most effective (Virk, 2008). Beyer explains the biofortification of rice through genetic engineering in a simplistic way:

> The ordinary pathway for plants synthesizing beta-carotene is well known, but four of the genes involved are missing in rice. In Golden Rice, part of this gap was filled with one single gene from the soil bacterium *Erwinia herbicola*, producing one single enzyme replacing a pathway for which plants need three genes producing three enzymes, achieving the same result. That is a significant simplification of the technology. (Beyer, 2008)

Importantly, the daffodil and bacterium genes have no risk for being allergens either. This is significant to note because a key argument and fear of opponents of biotechnology pertains to allergens, which should be put to rest for Golden Rice.

A common criticism of genetically modified organisms is that there are current traditional interventions that are working. One of the most common traditional solutions to vitamin A deficiency is vitamin A capsules. However, Golden Rice offers a solution to vitamin A capsules. Approximately 500 million vitamin A capsules are distributed annually, which amounts to an estimated cost of 5 billion dollars over ten years. In comparison, the cost for Golden Rice breeding is merely one percent of the vitamin A capsule's annual cost (Beyer, 2008). The benefits of Golden Rice over vitamin-A capsules may also be seen by evaluating the possible health benefits for Golden Rice compared to the potential risks that vitamin A capsules pose. With vitamin A there is risk of possible overdose, whereas the insertion of beta-carotene (pro-vitamin A) in Golden Rice comes with an inability to overdose. This is because the beta-carotene in Golden Rice allows the body to naturally regulate how much provitamin A will be converted into vitamin A (Potrykus, 2008). The hypothetical risks of Golden Rice that are proposed by opponents of biotechnology are nonexistence according to testing performed by many scientists. Yet experiments have not been permitted to be performed in fields, rather than in greenhouses, for approximately ten years (Potrykus, 2008). So, while Golden Rice is clearly superior to traditional vitamin-A capsules, when evaluated there are many factors holding back the production and distribution of Golden Rice.

Biofortified food crops have the potential for cost-effective nutritional improvement through a one-time investment that generates return yearly (Meenakshi, 2008). However, the lacking mechanism for the humanitarian project of Golden Rice in the public domain is due to the absence of expected financial return, where sadly there is no perceived incentive for an industry to develop a product that is simply for the sake of charity (Potrykus, 2008). Golden Rice is not allowed to be produced for profit, but should only be produced for the wellbeing of underprivileged, poor, developing countries as consumers (Dubock, 2008). For this reason, this humanitarian intervention seems quite appealing. The problem is that there becomes no incentive for production of Golden Rice by the rich and greedy. The success of Golden Rice then becomes dependent on the public support of its technological development, release, and distribution, where Golden Rice should be seen as a complement, rather than a replacement, for traditional interventions (Qaim, 2008). The impact of Golden Rice will depend on rice consumption, efficacy as judged by the amount of beta-carotene contained in the grain and its availability to the body, and the total coverage of rice consumption replaced by Golden Rice through consumer and farmer acceptance (Qaim, 2008). Barry conveys that government support and public research sector programs are essential to informing one another and policy makers toward the awareness and benefits that biotechnology developments can offer worldwide (Barry, 2008).

Finding financial support, coping with patent requirements, coping with regulatory requirements, resisting negative attitudes, getting the product to the market, and technological acceptance are all obstacles that Golden Rice is currently facing (Potrykus, 2008). Political and social attitudes need to be overcome, but product supply, lack of money, and decreased research and marketing pose serious problems beyond the already restrictive regulatory requirements. Dubock describes this problem of marketing by explaining, "Normally growers cultivate something because there is an economic benefit to it. Now, we have to induce them to grow" (Dubock, 2008). Another setback for Golden Rice due to regulations is that, as a genetically modified organism, Golden Rice cannot be taste-tested by consumers prior to completion of all regulations and tests. This ceases effective marketing, distribution, and product awareness. In many developing countries there is currently no consumer marketing for the sole fact that there is no money to buy consumer goods. This means that marketing approaches must be done from scratch, which appears to have its advantages and disadvantages. Having no previous consumer marketing is problematic because this means that there is not already a basis for judging what the consumer is looking for. However, since everything has to be made from scratch this provides the opportunity for utilizing a range of marketing research tests for Golden Rice, which include: taste, appearance, daily usage in menus, whether or not Golden Rice lends itself to indigenous cooking experiences, comparable pricing to other items on the market, usage over time, methodology of planting, and the impact of the brand (Dubock, 2008).

There is a complex challenge of social marketing that is unique to Golden Rice (Potrykus 2008). These marketing systems are necessary for seed distribution in order to ensure that Golden Rice consumption will be of the highest benefit to each marginalized member of society. Consumer acceptance needs to be well researched (Meenakshi, 2008). Finding out what appeals to the consumers, in addition to what the consumers need, is essential for Golden Rice's success. Determining the relationship between product characteristics with farmer and consumer needs helps to establish the most effective communication as to what would motivate farmers in planting, and consumers for eating, Golden Rice. Dubock explains that the conventional marketplace concentrates on the "six Ps," as essential for good marketing of Golden Rice: getting to know the product, knowing the people in each community, finding the best place for distribution, positioning the product to allow for the greatest amount of acceptance, getting the price to be no higher than the normal rice currently being marketed, and knowing how to promote Golden Rice in a way that communicates its importance (Dubock, 2008). Social marketing involves increasing coverage by attempting to gain acceptance for the color and variety that Golden Rice offers (Meenakshi, 2008).

Ignoring the benefits of Golden Rice can only be accepted for so long. Something needs to be done about the regulations that are causing millions of deaths, infectious diseases, and poor immune systems worldwide. The regulations of genetically modified organisms are especially strict in Europe, which has created separate institutions and processes that could stifle this technology indefinitely. There is no known evidence of risks such as allergens or toxicity, therefore the precautionary principle for this biofortification is ridiculous. This is especially frustrating considering that there has been official agreement that there is no evidence of any health-related or environmental risks from any genetically modified organisms thus far (Paarlberg, 2008). Paarlberg explains that, “it is not the presence of direct risks; it is the absence of direct benefits that affects the attitude.” If there is no evidence of risk then it seems that opposition to genetic engineering is merely due to the rejection of technology. A regulatory system should allow technologies into the market if there is no known public risk. In the case of Golden Rice, to think that beta-carotene, which may be found in numerous products that are currently consumed worldwide and has known health benefits, is under strict regulations and testing, is completely astounding. The benefits of eating far outweigh the unfounded hesitancy of the damage that *may* be done by consumption (Virgin, 2008). The largest risk for Golden Rice is not utilizing it.

There needs to be a balance between hypothetical hazards and real benefits. Investing too much in regulation and control of a product that has no known risk is worthless. The only real precautions that should have been taken for Golden Rice are the assessments of safety pertaining to the two genes that were inserted into the rice, maize and the bacterium *Erwinia uredovora*, along with the evaluation of beta-carotene levels and the overall composition of the rice. The over-regulation of transgenic crops with no obvious safety risks should not be occurring. Conventional breeding actually poses more of a threat to changes in DNA than genetically modified crops because biofortification results in a more precise technology (Chassy, 2008). Focusing on the traits in the host plant and in the genes introduced to the host plant should be the only relevant concerns present in transgenic plant regulation (Miller, 2009). Chassy rightly argues that, “putting huge amounts of money into minuscule hypothetical risks damages public health by diverting resources and distracting the public from major risks" (Chassy, 2008). Resources should not be wasted on regulations and testing but should focus on providing food and micronutrients to those in need. Products are currently regulated on a case by case review and should be based on the properties of the product. However, products are regulated on the basis of techniques used, which is costly in terms of both human suffering and economic monetary losses (Miller, 2008). Challenging governmental policy making through means of public awareness is essential to biotechnology's advancement. Since national arrangements for biosafety vary from country to country it is imperative that costs be minimized, avoiding testing duplication and to stimulate procedures for transgenic approval (Wakhungu, 2008). It is important to be careful when using the word "biosafety," though, because to do so compiles all safety issues for biotechnological discoveries, allowing for a generic legislation and regulation (Cantley, 2008). Biofortification of rice offers a solution for malnutrition and vitamin A deficiency that is a sustainable, long-term solution for a growing world population that faces thousands of deaths per day (Mayer, Pfeiffer & Beyer, 2008). It is imperative that these technological regulations do not continue because the people who have the greatest need have little voice or influence. Since agricultural biotechnology enables more efficient and precise breeding systems, which improves productivity and quality of crops, this technology needs to be embraced and awareness needs to be spread, because population sustainment is dependent on this kind of innovation (Leaver, 2008).

In conclusion, worldwide malnutrition and vitamin-A deficiency are annually causing millions of children to suffer from blindness, poor immune functioning, infectious diseases, and death. Every year more than 10 million children die of malnutrition with a vast majority of deaths being linked to micronutrient deficiencies. This inadequate intake of protein, energy, and micronutrients is most notable in Vitamin A deficiency, which is the leading cause of child blindness. Vitamin A deficiency causes half a million children to become blind annually, and 50 percent of children die within one year of becoming blind. Vitamin A deficiency is most prevalent among those who are dependent on rice as their predominant food source, which is approximately 400 million rice-consuming poor (Golden Rice Humanitarian Board, 2005-2011). Indigenous rice does not contain pro-vitamin A, which the body needs in order to be converted into vitamin A. The proposed solution to malnutrition and vitamin-A deficiency in developing countries is Golden Rice, which is genetically modified rice through the biofortification of beta-carotene in the rice endosperm. Golden Rice is one step toward making a difference, given its compatibility with traditional farming systems and inconceivable risks to both the consumer and the environment. A single plant of Golden Rice produces approximately 1,000 seeds, which, over the span of two years, generates 28,000 metric tons of rice. This allows for 100,000 people to be fed for an entire year (Golden Rice Humanitarian Board, 2005-2011). Golden Rice allows for the transference of pro-vitamin A into a country's local variety of rice through conventional backcrossing, therefore providing each country with a biofortified rice that is specific to the needs of that region. The unfortunate diffidence toward transgenic technologies out of fear for unpredictable genome alterations needs to be addressed and nullified. This hesitancy is unreasonable given that traditionally bred agriculture regularly undergoes breeding that is much less precise than the biofortification of Golden Rice. Potrykus explains that, “Had Golden Rice not been genetically modified, it would have been in use since 2002. Now it is taking ten years longer, causing up to 400,000 unnecessary deaths in India alone, for no other reason than the regulatory system established world-wide with financial support from the United Nations" (Potrykus, 2008). There is a moral imperative to promote genetically modified crops for the potentiality of helping the developing world, and until reasonable agricultural regulations of genetically modified organisms transpire, the illegitimate fears of transgenic plants will continue to cause unjustified, ubiquitous deaths.

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