Effects of Information on Consumers’ Willingness to Pay for Golden Rice*

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We examine the effects of information on consumer bidding behavior using a uniform-price auction with four units supply for golden rice. Our findings show that mean willingness to pay (WTP) bids are highest under positive information, followed by no information, negative information, and unexpectedly lowest with two-sided information. Participants might have put more weight on the negative when faced with both positive and negative information. There is also a minor difference in WTP with respect to the reference price between positive information and no information. Furthermore, the marginal effect on WTP of positive information vis-à-vis no information is minimal. This suggests that the positive information faced by consumers might not be compelling enough to drastically increase WTP bids for a genetically modified product such as golden rice.

Keywords: bidding behavior, consumers’ willingness to pay, uniform-price auction, golden rice, information effects.

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I. Introduction

Studies on the effect of type of information on consumer acceptance have yielded inconsistent findings (Fox et al. 2002; Tegene et al. 2003; Lusk et al. 2004a,b; Rousu et al. 2005; Hu et al. 2006; Huffman et al. 2006). As such, consideration of the effects of information on consumer acceptance of new products has become a fertile ground for applied research.

One such novel product is golden rice, which has been genetically modified to produce provitamin A in rice intended for consumption in most developing countries. The latest version of golden rice has reportedly been given the go-ahead for trial plantings in India and the Philippines (New Scientist, 2005). A still
unresolved issue regarding golden rice, as identified by Robertson et al. (2002), is consumer acceptance. There are those who denounce this genetically modified (GM) food crop as a mere child of the biotech lobby and as a useless and rather harmful innovation for the poor (Zimmermann and Qaim, 2004). In connection with the aforementioned, the value of information as a contributory factor to consumer acceptance cannot be underestimated. Therefore, the present study attempts to assess the effects of different types of information on consumers’ willingness to pay (WTP) for golden rice. The findings can be used as a guide in the development of policies and marketing campaigns for golden rice.

Consumer acceptance of bioengineered foods is driven primarily by public perceptions of risks, benefits and safety of these food products (Hossain and Onyango, 2004). Research has shown that different types of information (i.e. favorable versus unfavorable) affect consumer perceptions, attitudes and, hence, behavior (Fox et al., 2002).

The use of experimental auctions to determine consumer acceptance and WTP for product attributes or new products is becoming increasingly popular (Umberger and Feuz, 2004). Knowledge regarding consumers’ WTP can be applied to pricing and new product development decisions (Breidert et al., 2006). In the present study, we use the uniform-price auction to elicit WTP for golden rice under different types of information.

The rest of the paper is organized as follows. Section II contains a review of valuation studies on the effects of information on valuation. The research design is described in Section III, and the experiment results are analyzed in Section IV. Conclusions are presented in Section V.

II. Information Effects

The second-generation GM crops are those that are bred for attributes desired by consumers. These are intended to directly benefit consumers rather than producers. Golden rice, which has been genetically engineered to contain a higher level of vitamin A, is a prime example of this class of second-generation GM crops. It is intended to improve the health of poor people in developing countries that rely on rice as their main staple food (Nielsen and Anderson, 2005).

Currently, scientists at the Philippine-based International Rice Research Institute are carrying out adaptive research to verify and improve the golden rice gene constructs and to incorporate them into popular indica varieties. Although golden rice is still at the R&D stage, it has already been surrounded by public controversy. Some consider it as a potential solution to overcoming malnutrition and Vitamin A deficiency (VAD). According to Zimmermann and Qaim (2004), although golden rice will not completely eliminate Vitamin A deficiency, which leads to blindness and increased mortality in the Philippines, it can lead to annual health improvements between US$16 and US$88 m per year, depending on the underlying assumptions.
During the past decade, efforts in terms of food fortification, supplementation and dietary education programs have been made to reduce VAD, which causes temporary and permanent eye impairments and increased mortality, especially among children and pregnant and lactating women in developing countries. Golden rice has several desirable features as a VAD intervention strategy because of the unique position of rice as the overwhelmingly dominant staple in Asia (Robertson et al., 2002).

The effect of information has been found to vary by type of information. Lusk et al. (2004b) found that information on environmental benefits, health benefits and benefits to the third world significantly decreased the amount of money consumers demanded or their willingness to accept (WTA) GM chocolate chip cookies. In contrast, Tegene et al. (2003), in an experimental auction where participants received pro-biotech, anti-biotech and both pro- and anti-biotech information, found that those who received only anti-biotech information bid less for the biotech-labeled foods by an average of 35 percent. They also discovered that individuals placed a slightly greater weight on negative information than on positive information. Hu, et al. (2006) likewise reported a similar trend when they found that media reports on positive real-life cases involving GM foods did not increase consumers’ WTP significantly, but reports on negative cases drastically lowered their WTP.

Several studies have evaluated the effect of new information on WTP for new products. For example, Rousu et al. (2005), using the Becker, DeGroot and Marschak mechanism auction, examine the effect of marketing information and labeling on consumer demand for cigarettes derived from genetically engineered (GE) tobacco to reduce nicotine levels. Participants in two of their four treatments received information sheets containing two statements regarding the GE brand of cigarettes. They found strong evidence that consumers who did not receive marketing information decreased their demand when there was a GE label, whereas consumers who received marketing information increased their demand for the product.

Lusk et al. (2004b), in a WTA study using fifth price auction, revealed that information on environmental benefits, health benefits and benefits to the third world significantly decreased the amount of money consumers demanded to consume (i.e. WTA) GM food.

A more recent topic of interest concerns the provision of both positive and negative information, or ‘two-sided persuasion’ information, as a message strategy in promoting products deemed by consumers as risky. According to Crowley and Hoyer (1994), two-sided information (i.e. positive and negative information are presented) is a more effective persuasive device and this can be attributed to two-sided messages being able to: (i) enhance credibility; (ii) reduce counter-arguing; and (iii) generate attitudinal resistance to attack. However, Fox et al. (2002) find that when participants are faced with conflicting positive and negative information, the latter dominates the former, which leads to participants putting more weight on negative information and to a consequent decrease in WTP.
values. Fox et al. (2002) offer four possible reasons for the dominance of negative information over positive information: (i) loss aversion type behavior (based on the prospect theory) – from a given reference point, monetary losses associated with switching to an alternative are given greater weight than corresponding gains (Kahneman and Tversky, 1979); (ii) bias in favor of ‘status quo’ alternatives (Samuelson and Zeckhauser, 1988); (iii) ambiguity aversion (e.g. conflicting descriptions of a product), as mentioned by Fox and Tversky (1995); and (iv) risk aversion in learning – a tendency for people to place greater weight on the worst case scenario when alternative risk estimates are provided (Viscusi, 1997).

Tegene et al. (2003) report that among nth-price auction participants who received positive, negative and both positive and negative information about agricultural biotechnology, those who received only negative information bid on average 35 percent lower for the biotech-labeled foods vis-à-vis than for plain-labeled food. In contrast, those who received both positive and negative information were willing to pay for GM-labeled food by less than 16–29 percent vis-à-vis the plain- (or standard) labeled food depending on the product.

More recently, Huffman et al. (2006), using random nth-price auction, study how prior information affects the interpretation of new information. They report that individuals who had informed prior beliefs about genetic modification coming into the experimental auctions discounted GM-labeled food products more highly than those participants with uninformed prior beliefs. They added that the behavior of those who were informed suggests that their prior information was somewhat negative. In contrast, participants who had uninformed prior beliefs about genetic modification before their experiments exhibited the greatest change in bidding behavior, and this was attributed to the injection of new information. Their findings reveal that the mean difference in bid prices for plain-labeled less GM-labeled food among informed participants (who did not receive third-party GM information) was biggest among those given only anti-biotechnology information, followed by those given pro-biotechnology and anti-biotechnology information, and lastly, pro-biotechnology information across products. Among the uninformed, the ascending order of mean difference was as follows: anti-biotechnology, pro-biotechnology and anti-biotechnology, and pro-biotechnology.

No other study, however, has evaluated the effect of different types of information on consumers’ WTP for golden rice. So far, the only WTP study on golden rice used the contingent valuation method (Lusk, 2003). Therefore, we attempt to contribute to the investigation of information effects by systematically examining the effects of various types of information on consumers’ WTP for golden rice.

III. Experimental Design

In an experimental auction individuals bid against others in an active market. In a WTP auction, the high bidder(s) wins the good and actually pays the market price. This method provides incentives for individuals to truthfully reveal their
values and imposes a cost for non-truthful (or inaccurate) value revelation. Experimental auctions can be undertaken in two ways: (i) consumers are provided with an endowed good (typically a pre-existing substitute) and are then asked to bid to exchange their endowed good for a novel good (Endowment Approach); or (ii) consumers bid directly on several competing goods (or in the present study’s case, one novel good) and a random drawing can be used to determine which good is binding so that demand for a single unit can be elicited (Lusk and Shogren, 2007).

We use the uniform-price auction with four units supply to elicit consumers’ WTP for golden rice. In this auction, participants are asked to state their WTP bids in multiple rounds and the top four bidders of the binding round are declared as winners and pay the fifth highest price.

We make use of four treatments representing different types of information about GM products: no information, positive, negative, and two-sided information. All the experimental sessions were conducted from late November to mid-December 2006. All subjects were students in the University of the Philippines Los Baños.

Upon arrival at the lab site, participants were given an ID number and a packet containing a payment coupon, a consent form, brief instructions, a questionnaire, experimental instructions and information sheets. They were asked to read and sign the consent form and the payment coupon, read together with the monitor the brief instructions for the experiment and complete a questionnaire containing questions about their demographic characteristics and level of awareness about genetic modification and GM food products.

The protocol for the uniform-price auction with four units supply and the actual conduct of the experiment are described in detail below.

The payment coupon informed the students that they would be receiving ₱100 (100 Philippine pesos) (US$1 = ₱50). The payment coupon informed the students that they would be receiving ₱100 (100 Philippine pesos). This was the incentive given to them for the time and effort allotted for the whole session. Each 1-hour session consisting of 25 participants was subjected to one information treatment following exactly the same protocol described in steps 1–6. First, subjects were asked to engage in a round of bidding on a candy bar to learn the mechanism of the uniform-price auction. The formal auction then followed. Each session represented one of the four information treatments: (i) positive information; (ii) negative information; (iii) two-sided information; and (iv) no information. All subjects within a particular session received the same information shock. The positive, negative and two-sided information shocks were related to food safety, human impact, socioeconomic impact and environmental impact of GM food products and golden rice (see Appendix 1 for the contents of the information treatment sheets). Positive information mostly came from information released by the Golden Rice Humanitarian Board, whereas negative information came from

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1. For those in the no information treatment, the packet did not include an information sheet.
Greenpeace and other international as well as local foundations and media sources. The two-sided information utilized the positive and negative information from the aforementioned sources. In the auction instructions, participants were given a reference price of Php15 per half-kilogram bag of regular rice. It was also emphasized to them that the winning bidders would actually pay money to purchase the golden rice. Finally, they were told that it was acceptable to bid Php0 in any round and that this would mean that they were not willing to pay for the golden rice at any price.

Step 1: Subjects were shown a bag of regular rice (i.e. not GM) and were informed that it can usually be purchased at a local store for approximately Php15 per one-half kilogram. They were likewise shown a sample bag (one-half kilogram) of golden rice (in actuality ordinary rice colored yellow to make it look like golden rice). They were also told that the golden rice was genetically modified to produce provitamin A (beta-carotene) and that other than the golden color, the bag of rice is the same size, weight, and has the same taste as the rice that they had been shown previously.

Step 2: Prior to the real auction, the participants were asked to read the information sheets enclosed in their packets, return the information sheets inside the envelope, and wait for the signal from the monitor before proceeding to the next step.

Step 3: The participants were asked to indicate the highest amount of money they were willing to pay for the golden rice by writing their bids on the enclosed bid sheets.

Step 4: Step 3 repeated for four additional rounds. After each round, the ID numbers and the bids of the four highest bidders were posted in front of the room along with the fifth highest bid amount. Ties in bids were broken by tossing a coin in the case of two identical bids and making use of a random number generator (i.e. number of identical bids were inputted first) if there are more than two identical bids.

Step 5: At the completion of the fifth round, a random number (within 1–5) was drawn to determine the binding round. After which, the four winning bidders in the binding round were asked to pay the fifth highest bid amount to be able to buy the golden rice.

Step 6: Winners were given a claim certificate for a half-kilogram bag of golden rice and Php100 less the fifth highest bid amount. They were then instructed to pick up their golden rice on a future date announced by the monitor (after all the experiments have been conducted). Participants were asked not to discuss the study with anyone.

IV. Result

Table 1 summarizes the demographic characteristics of the student subjects. The majority of the participants are women who seldom buy uncooked rice and claim
to be informed about golden rice. Students who deem golden rice as safe slightly outnumber those who claim that it is not safe.

### IV.1 Information effects

To explore the influence of new information on WTP using the uniform-price auction, we present various summary statistics for the WTP bids for the different information groups. Table 2 exhibits the means and medians of the WTP bids under the uniform-price auction.

For the mean bids, the auction WTP results are as follows: positive > no information > negative information > two-sided information. However, this is not the case for median bids where the positive information median bid was both lower than the no information median WTP and even equal to the negative information median bid. The two-sided information treatment unexpectedly generated lower mean and median WTP bids than the no information treatment.

The above findings are not consistent with the finding of Tegene et al. (2003) that the WTP bids across treatments were in ascending order as follows: positive,
followed by two-sided information, and lastly by negative information. Likewise, Huffman et al. (2006) found that the mean difference in bid prices for plain-labeled less GM-labeled food among informed as well as uninformed participants was biggest among those given only anti-biotechnology information, followed by those given pro-biotechnology and anti-biotechnology and lastly, pro-biotechnology information across products.

For the two-sided treatment, participants may have put more weight on the negative when faced with both positive and negative information. Fox et al. (2002), in explaining why there was a decrease in WTP for irradiated pork after subjects were given both the pro-irradiation and anti-irradiation descriptions, related the dominant effect of negative information to the loss aversion theory; that is, from a given reference point, monetary losses associated with switching to an alternative are given greater weight than corresponding gains. This results in a bias in favor of the status quo (i.e. typical pork) and was manifested by the unexpected decrease in WTP for a pork sandwich irradiated to control *Trichinella* and downgraded safety assessment for irradiated pork. Fox et al. also added the idea that there might be a general bias in favor of ‘status quo’ alternatives across a range of decision environments. In particular, when subjects are confronted with conflicting (i.e. positive and negative descriptions of the irradiated alternative) information, the decision environment might be one in which the ‘status quo’ familiar product is favored.

The study by Tegene et al. (2003) on the effects of information on consumer demand for biotech foods also indicates that individuals placed a slightly greater weight on negative information than on positive information.

There is a minor difference in WTP with respect to the reference price between positive information and no information. As expected, the magnitude of the differences in WTP to the reference price of ₱15 per half-kilogram bag is highest under positive information (₱9), followed by no information (₱6). For the negative and two-sided information, the WTP are lower by ₱2 and ₱4 than the reference price, respectively.

The ratios of mean and median WTP of the three other groups to the no information group were also calculated. Table 3 shows the results. Given positive information, the change in mean WTP is 47 percent; for the negative information group, −38 percent; and −48 percent for the two-sided information group. This finding reinforces the outcome of the mean and median bid analysis presented in
Table 2. It is interesting to note that there are conflicting results for the positive information group. For the mean bid, there is a 47 percent increment while for median WTP, the change is –25 percent.

IV.2 Regression analysis

To complement the previously presented mean and median bid analysis, OLS regression was undertaken with WTP bids as the dependent variable. The independent variables are the information groups and rounds (represented as dummy variables), as well as demographic, consumption-related and level of awareness factors.2 Demographic variables that have a statistically significant effect on WTP are gender, frequency of buying rice, and age. In addition, the participants’ level of awareness about golden rice and opinion on safety of golden rice are not statistically significant. Table 4 reports the regression results.

Two-sided information is found to have a larger negative effect on WTP bids than negative information, which contradicts the findings of past studies.3 The decrease in WTP vis-à-vis the reference price of ₱15 per half-kilogram is 12.43 for two-sided information and 8.48 for negative information. It can be observed that after including other variables (i.e. demographic, consumption and level of awareness variables), the positive information effect turned out to be small (1.16) and not statistically significant, although it still conforms to the hypothesized sign. It is interesting to note that with no information, there is a decrease of 5.59 in WTP. Furthermore, the estimated round effects are all positive, increasing, and highly statistically significant, indicating that the bidders tend to start with lower bids and steadily increase their bids in multiple round auctions.

Finally, we calculate the marginal effect of information on WTP by dividing the regression coefficients of the information treatments with the mean WTP of the base group (with no information). Table 5 presents the calculated marginal effect of information on WTP indicators. This indicator captures the change in the

2. Other studies that have included ‘rounds’ as right-hand variables include Drichouits et al. (2008, 2009), Corrigan et al. (2009) and Depositario et al. (2009). Rounds represented by dummy variables were incorporated in the model to capture possible round effects (e.g. bidders might start with lower bids and increase their bids in multiple round auctions).
3. Tegene et al. (2003) and Huffman et al. (2006).
dependent variable when there is a 1-unit change in the independent variable under consideration. When the independent variable is binary, it captures the effect of that binary variable on the dependent variable when its status switches from zero to one.

The marginal effect on WTP of positive information vis-à-vis no information is minimal. In contrast, the adverse marginal effects of negative and two-sided information on WTP bids are substantial.

### Table 4 Regression results on willingness to pay

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>−5.59</td>
<td>−0.51</td>
</tr>
<tr>
<td>Positive information</td>
<td>1.16</td>
<td>0.64</td>
</tr>
<tr>
<td>Negative information</td>
<td>−8.48</td>
<td>−5.56***</td>
</tr>
<tr>
<td>Two-sided information</td>
<td>−12.43</td>
<td>−7.46***</td>
</tr>
<tr>
<td>Round 2</td>
<td>4.36</td>
<td>2.62***</td>
</tr>
<tr>
<td>Round 3</td>
<td>7.28</td>
<td>4.36***</td>
</tr>
<tr>
<td>Round 4</td>
<td>11.66</td>
<td>6.99***</td>
</tr>
<tr>
<td>Round 5</td>
<td>13.18</td>
<td>7.90***</td>
</tr>
<tr>
<td>Gender</td>
<td>−7.92</td>
<td>−6.72***</td>
</tr>
<tr>
<td>Age</td>
<td>1.40</td>
<td>2.52**</td>
</tr>
<tr>
<td>Classification of year in college</td>
<td>−2.52</td>
<td>−0.97</td>
</tr>
<tr>
<td>Household size</td>
<td>0.12</td>
<td>0.54</td>
</tr>
<tr>
<td>Family income</td>
<td>−0.15</td>
<td>−1.37</td>
</tr>
<tr>
<td>Frequency of buying rice</td>
<td>−4.83</td>
<td>−4.28***</td>
</tr>
<tr>
<td>Level of awareness about golden rice</td>
<td>1.69</td>
<td>1.41</td>
</tr>
<tr>
<td>Bidder opinion on safety of golden rice</td>
<td>−0.66</td>
<td>−0.56</td>
</tr>
<tr>
<td>Multiple $R^2$</td>
<td>−0.3544</td>
<td></td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>−0.3339</td>
<td></td>
</tr>
</tbody>
</table>

*** and ** represent statistical significance at the 1 and 5-percent level, respectively.

### Table 5 Marginal effect of information on willingness to pay (WTP)

<table>
<thead>
<tr>
<th>Information treatments</th>
<th>Positive</th>
<th>Negative</th>
<th>Two-sided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information effect on WTP</td>
<td>0.06</td>
<td>−0.40</td>
<td>−0.59</td>
</tr>
</tbody>
</table>

* Regression coefficient for an information treatment divided by mean WTP of the base group (with no information).

V. Conclusions

Golden rice is an important GM food product that could potentially mitigate problems of blindness and premature deaths around the world, especially in many...
developing countries. Therefore, it is important to investigate consumers’ perceptions of this product. Because golden rice is a second-generation GM product offering tangible consumer benefits, the expectation is that market acceptance will perhaps be significantly higher than the first-generation GM crops with benefits focused mainly on the input traits. In the present study, we investigate consumers’ acceptance of golden rice focusing on the effects of information on WTP using the uniform-price auction. Our results show that the auction WTP mean bids are highest under positive information, followed by no information, negative information, and, lastly, under two-sided information. The latter treatment generating lower mean and median WTP than the no information treatment was unexpected. It is probable that the participants put more weight on negative information when faced with both positive and negative information and, paradoxically, the overall result was a decrease in WTP similar to the research findings of Fox et al. (2002). There is a small difference in WTP with respect to the reference price between positive information and no information. We also observe that the marginal effect on WTP of positive information vis-à-vis no information is minimal. This suggests that the positive information presented to consumers might not be as compelling to drastically increase WTP bids for golden rice. The more practical option in promoting golden rice would be to maintain the status quo; that is, to not conduct aggressive information dissemination campaigns concerning golden rice up until researchers and policy-makers are sure about the exact positive information that would effectively lead to consumer acceptance of second-generation GM food products. Further research can also look more closely into the impact of two-sided information on consumer acceptance.

Appendix I: Information Sheets for Auction

Information treatment 1 (Positive Information)

Food safety

The US Food and Drug Administration (FDA), which has one of the most stringent food evaluation policies, has determined that plant foods produced through biotechnology present no inherent food safety risk different from conventionally bred plants. Furthermore, extensive food safety evaluations have been implemented to minimize the possibility that allergenic proteins are introduced into commercialized GM crops. There is no single commercialized GM plant that is known to cause any significant risks of allergenicity.

It is also worth noting that natural foods account for majority of food allergies such as shrimps, crabs, and nuts and that in fact, any food that contains proteins has the potential to cause allergic reactions depending on individual susceptibility.

The FDA has approved GM food for human consumption. Americans have been consuming GM foods for years and there has never been a documented case of a person getting sick from GM food.
Human impact

Golden Rice has the potential of improving millions of lives a year by reducing the cases of VAD. It is expected to provide nutritional benefits to those suffering from vitamin A deficiency-related diseases, including irreversible blindness found each year in hundreds of thousands of children in third-world countries. Adequate consumption of this rice also can reduce the number of deaths associated with infectious diseases, such as diarrhea and childhood measles, by improving the immune system.

Golden Rice aims at improving the health of poor people in developing countries which rely on rice as their main staple food. The genetic modification to make rice produce provitamin A (beta-carotene) is seen as a simple and less expensive alternative to vitamin supplements or an increase in the consumption of green vegetables or animal products. It can be considered as the genetically-engineered equivalent of fluoridated water or iodized salt. This is a welcome development as those who most need the product of this new technology are those who can least afford buying a mixed diet, rich in various nutrients.

Socio-economic impact

Contractual arrangements made by the inventors of Golden Rice with various companies will have positive implications for the accessibility, availability, and affordability of Golden Rice seeds to farmers around the world. Shortly after the discovery of the first version of Golden Rice, the inventors signed a deal with AstraZeneca (now Syngenta) which gave the latter full commercial rights to the invention worldwide and ‘non-commercial’ rights to the investors for license-free use by national and international research institutes and resource-poor farmers in developing countries. AstraZeneca agreed to waive technological fees to enable the development of the rice for ‘humanitarian’ purposes. Monsanto and 5 other private companies also announced royalty-free licenses for any of its technologies used to further the development of the rice. The intention is to introduce Golden Rice into publicly-owned rice varieties via national and international public sector research institutions, to be made available free of charge to resource-poor farmers. The farmers will then be able to grow, save, consume, replant and sell on a small scale into the local economy the resulting rice crop.

The contractual arrangements will guarantee free access for farmers to the technology. Golden Rice is expected to become widely and cheaply distributed through the farmers’ own supply and exchange networks. Farmers can keep the seeds for future sowing and this will reinforce and repeat the initial distribution of seed.

Environmental impact

The expected adverse effect on the environment such as horizontal gene transfer (the transfer of transgenic DNA from GM plants to soil fungi and bacteria) and
outcrossing (or the movement of genes from GM plants into conventional crops or related species in the wild) are natural events that occur at an extremely low rate.

In relation to horizontal gene transfer, there is no reason why the Golden Rice genes should be preferentially transferred over 30-thousand-plus other genes in the genome, and if this happened those genes would only be able to participate in the biosynthesis of carotenoids, which is ever-present in nature, especially in our food. The DNA of transgenes is no more or less stable than any other DNA, it will be degraded in the ground at the same rate as the remaining genomic DNA. Likewise, the chances of outcrossing to non-transgenic rice and wild species are very low.

Information treatment 2 (negative information)

Food safety

One issue raised against GM food products is its safety, specifically its allergenicity or its tendency to provoke allergic reactions. Likewise, the transfer of genes from commonly allergenic foods could pose a problem for those already allergic. There is also a possibility of the creation of new allergies.

Furthermore, there is the possibility of gene transfer or genes being potentially transferred from GM foods to cells of the body or to bacteria in the gastrointestinal tract. This could have a negative effect on human health, such as the transfer of antibiotic-resistant genes to humans.

Human impact

The very notion that Golden Rice could have ‘a real impact on the health of children living in Southeast Asia’ deserves critical scrutiny. Consideration of basic principles of nutrition suggests that rice containing ß-carotene is unlikely to alleviate vitamin A deficiency. To begin with, the bioavailability of ß-carotene is quite low-10% or less by some estimates. Analysis reveals that people would need to consume 12 times more rice than normal to satisfy the minimum daily adult requirement of Vitamin A.

With what has been shown so far, 300 grams of golden rice can only provide at most 20% of an adult’s daily vitamin A requirement. A child would have a lower requirement of 450 µg retinol as against 500–600 µg retinol for adults. But 300 g of rice is way too much for a child. In the Philippines, pre-school children consume less than 150 grams of rice a day. In principle then golden rice will only supply a little over 10% of the daily vitamin A needed by pre-school children.

Also, the digestion, absorption, and transport of ß-carotene require a functional digestive tract, adequate protein and fat stores, and adequate energy, protein and fat in the diet. Many children exhibiting symptoms of vitamin A deficiency, however, suffer from generalized protein-energy malnutrition and intestinal infections that interfere with the absorption of ß-carotene or its conversion to vitamin A.
Socio-economic impact

There is a perception that small-scale farmers could be ‘negatively impacted by the market dominance of a few powerful seed companies’. While Syngenta and other companies claim that they do not see a commercial market in the developing countries, it appears to some that GM foods are being pushed onto consumers by big businesses with the hidden agenda of having a captive market (composed of the farmers in the developing world) for their high-priced rice seeds. Traditional farming practices such as collecting, storing, and replanting seed may be lost as farmers are forced to buy F1 seeds from the private companies every planting season.

Thus, largely as a result with the deal of the developers of Golden Rice with Syngenta and other private seed companies, the cost of seed will be higher. Shortly after the discovery of the first version of Golden Rice, the inventors signed a deal with AstraZeneca (now Syngenta) which gave the latter full commercial rights to the invention worldwide and ‘non-commercial’ rights to the investors for license-free use by national and international research institutes and resource-poor farmers in developing countries. AstraZeneca agreed to waive technological fees to enable the development of the rice for ‘humanitarian’ purposes. Monsanto and 5 other private companies were quick to jump on the humanitarian bandwagon by announcing royalty-free licenses for any of its technologies used to further the development of the rice.

The terms of the ‘free license’ agreements are however still unclear: they appear to cover research, but not release or commercialization. This lack of clarity casts a huge question mark over how ‘free’ the agreement really is and has huge implications for the accessibility, availability and affordability of Golden rice to farmers around the world.

The other socio-economic issues raised against Golden Rice are as follows: 1) it would increase dependence of farmers on agrochemical inputs, which again would mean higher production costs to farmers; 2) the costs of supplying Golden Rice may also be high due to higher costs related to keeping Golden Rice production and marketing channels separate from other rice channels; and 3) because genetic modification improves the final quality characteristics of a product to the benefit of the final consumer, the seeds of this type of crop and its products may sell at a higher market price.

Environmental impact

Golden Rice has all the environmental risks of any GM crop – outcrossing and horizontal gene transfer. In relation to outcrossing, genes from GM plants can contaminate conventional crops in the wild through natural pollination and other processes (like wind). Furthermore, seeds from GM and conventional crops can inadvertently be mixed. This ‘outcrossing’ represents a threat to the future safety and security of the food supply, and has already occurred.
On the other hand, with horizontal gene flow or transfer, GM crops may have major impacts on the genetic content of the soil. Through a process that is poorly understood, bacteria and fungi are capable of capturing and using genetic material from their surroundings (for example, from decaying plant matter or micro-organisms). There are no procedures for recalling genetic material back from the soil once it is introduced and no techniques for predicting likely impacts.

_Information treatment 3 (two-sided information)_

Food safety

One issue raised against GM food products is its safety, specifically its allergenicity or its tendency to provoke allergic reactions. Likewise, the transfer of genes from commonly allergenic foods could pose a problem for those already allergic. The possibility of the creation of new allergies has also been brought up.

Furthermore, there is the possibility of gene transfer or genes being potentially transferred from GM foods to cells of the body or to bacteria in the gastrointestinal tract. This could have a negative effect on human health, such as the transfer of antibiotic-resistant genes to humans.

However, contrary to the perception of the allergenicity of GM food products, an experts committee convened by the United Nations Food and Agriculture Organization (UN-FAO) and World Health Organization (WHO) concluded that the possibility of allergies arising from the consumption of modified foods is no different from that of other conventionally produced or natural foods. Furthermore, extensive food safety evaluations have been implemented to minimize the possibility that allergenic proteins are introduced into commercialized GM crops. There is no single commercialized GM plant that is known to cause any significant risks of allergenicity.

It is worth noting that it is natural foods that account for majority of food allergies such as shrimps, crabs, and nuts. In fact, any food that contains proteins has the potential to cause allergic reactions depending on individual susceptibility.

Furthermore, as a matter of principle, the transfer of genes from commonly allergenic foods is discouraged unless it can be demonstrated that the protein product of the transferred gene is not allergenic. However, according to a University of California professor, allergenicity is not easily predictable. A gene extracted from one source may not be allergenic; however, in the transgenic product the novel gene can cross react with other proteins or be over expressed and cause an allergic response in the consumer.

Overall, there is not much research showing evidence that GM foods are hazardous to consumers; however, it is suggested that a systematic protocol should be developed by the existing food regulation organizations to evaluate the safety of new GM food products.
Human impact

The very notion that Golden Rice would be effective in addressing Vitamin A deficiency is questionable. Analysis reveal that people would need to consume 12 times more rice than normal to satisfy the minimum daily adult requirement of Vitamin A.

The bioavailability of β-carotene is quite low—10% or less by some estimates. Children in the developing world will have to eat an unrealistic amount of Golden Rice in order to reduce VAD.

Since the daily average requirement of vitamin A is 750 micrograms of vitamin A and 1 serving contains 30 g of rice according to dry weight basis, vitamin A rice would only provide 9.9 micrograms which is 1.32% of the required allowance. Even taking the 100 g figure of daily consumption of rice used in the technology transfer paper would only provide 4.4% of the RDA. In order to meet the full needs of 750 micrograms of vitamin A from rice, an adult would have to consume 2 kg 272 g of rice per day. This implies that one family member would consume the entire family ration of 10 kg. from the PDS in 4 days to meet vitamin A needs through ‘Golden rice’.

As a counter-argument to the above, the figures cited are based on the assumption that for malnourished children, Golden Rice will need to make up the entire recommended daily intake (RDI) of vitamin A. This standard is not the benchmark for success for the Golden Rice project. In fact, VAD occurs as a result of a deficiency of vitamin A, not necessarily complete lack thereof. Therefore, adding beta-carotene in even incremental amounts to one of the staple foods of the developing world has the potential to substantially relieve VAD symptoms.

Secondly, it has become clear now that in the originally estimated level of beta-carotene content that could be achieved in the genetically engineered grain (upon which much of the calculation supporting the early criticism was based) was strongly underestimated. New developments have led to beta-carotene content levels substantially higher again – up to 23 times the originally estimated figure.

The genetic modification to make rice produce provitamin A (beta-carotene) is seen as a simple and less expensive alternative to vitamin supplements or an increase in the consumption of green vegetables or animal products, especially in developing countries which rely on rice as their main staple food. It can be considered as the genetically-engineered equivalent of fluoridated water or iodized salt. This is a welcome development as those who most need the product of this new technology are those who can least afford buying a mixed diet, rich in various nutrients.

Socio-economic impact

There is a perception that small-scale farmers could be ‘negatively impacted by the market dominance of a few powerful seed companies’. While Syngenta and other companies claim that they do not see a commercial market in the developing countries, it appears for some that GM foods are being pushed onto consumers by
big businesses with the hidden agenda of having a captive market (composed of the farmers in the developing world) for their high-priced rice seeds. Traditional farming practices such as collecting, storing, and replanting seed may be lost as farmers are forced to buy F1 seeds from the private companies every planting season.

Thus, largely as a result with the deal of the developers of Golden Rice with Syngenta and other private seed companies, the cost of seed will be higher. Shortly after the discovery of the first version of Golden Rice, the inventors signed a deal with AstraZeneca (now Syngenta) which gave the latter full commercial rights to the invention worldwide and ‘non-commercial’ rights to the investors for license-free use by national and international research institutes and resource-poor farmers in developing countries. AstraZeneca agreed to waive technological fees to enable the development of the rice for ‘humanitarian’ purposes. Monsanto and 5 other private companies were quick to jump on the humanitarian bandwagon by announcing royalty-free licenses for any of its technologies used to further the development of the rice.

The terms of the ‘free license’ agreements are however still unclear: they appear to cover research, but not release or commercialization. This lack of clarity casts a huge question mark over how ‘free’ the agreement really is and has huge implications for the accessibility, availability and affordability of golden rice to farmers around the world.

However, the Golden Rice Humanitarian Board asserts that Syngenta has no commercial interest in Golden Rice in respect of its potential use or application in developing countries. It does not see a commercial market for Golden Rice in the developed world either. The technology is being donated by the inventors and Syngenta to the resource-poor farmers of developing countries. Syngenta is donating selected transgenic Golden Rice events to the Golden Rice Humanitarian Board and their development will be the responsibility of the Board and public institutes, which are the licensees.

As to the claim that Golden Rice will make the cost of rice seeds higher to farmers, there is a counter-argument that Golden Rice is actually expected to become widely and cheaply distributed through the farmers’ own supply and exchange networks. As Golden Rice will be introduced into publicly-owned rice varieties via national and international public sector research institutions and is made available by governments free of charge to resource-poor farmers, there will be free access among farmers to the technology. They will then be able to grow, save, consume, replant and sell on a small scale into the local economy the resulting rice crop. Farmers can keep the seeds for future sowing and this will reinforce and repeat the initial distribution of seed. No new dependencies will be created.

Environmental impact

The main environmental issues linked to GM food products are outcrossing and horizontal gene transfer. Genes from GM plants can contaminate conventional
crops in the wild through natural pollination and other processes (like wind). Further, seeds from GM and conventional crops can inadvertently be mixed. This ‘outcrossing’ represents a threat to the future safety and security of the food supply, and has already occurred.

On the other hand, with horizontal gene flow or transfer, GM crops may have major impacts on the genetic content of the soil. Through a process that is poorly understood, bacteria and fungi are capable of capturing and using genetic material from their surroundings (for example, from decaying plant matter or microorganisms). There are no procedures for recalling genetic material back from the soil once it is introduced and no techniques for predicting likely impacts.

While the chances of out-crossing to non-transgenic rice are very low (but not zero) the relevant issue is what effect the genes would have if outcrossing occurred. No selective advantage for the recipient plants would be expected from the outcrossing of the carotenoid genes from the Golden Rice. It should not be forgotten that practically all plants produce carotenoids, hence no new chemical compound is being introduced into the environment.

Research at the International Rice Research Institute (IRRI) and many studies have demonstrated that the chance of out-crossing from currently cultivated rice species is very low as these varieties are essentially self-pollinating. Moreover, rice pollen is only viable for 3–5 minutes. Where this may be an issue, the likelihood of outcrossing can be reduced significantly by appropriate measures such as staggered flowering dates and by observing recommended distances to other fields. While the chances of outcrossing to non-transgenic rice and wild species are very low (but not zero) the relevant issue is what effect these two well-characterized genes would have if outcrossing occurred.

With horizontal gene transfer, which has been demonstrated in laboratory experiments, GM crops may have major impacts on the genetic content of the soil. Transgenic DNA from GM plants can be transferred to soil fungi and bacteria. Through a process that is poorly understood, bacteria and fungi are capable of capturing and using genetic material from their surroundings (for example, from decaying plant matter or micro-organisms). There are no procedures for recalling genetic material back from the soil once it is introduced and no techniques for predicting likely impacts.

Horizontal gene transfers are natural events that occur at an extremely low rate. There is no reason why the Golden Rice genes should be preferentially transferred over 30-thousand-plus other genes in the genome, and if that happened those genes would only be able to participate in the biosynthesis of carotenoids, which is ever-present in nature, especially in our food. The DNA of transgenes is no more or less stable than any other DNA, it will be degraded in the ground at the same rate as the remaining genomic DNA.

References


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