Golden Rice: The Need, the Science, and Public Reception of GMOs

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Dr. Arezoo Rojhani, Family and Consumer Sciences

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Golden Rice: The Need, The Science, and Public Reception of GMO’s

Elizabeth Quemada

Honor’s Thesis

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Introduction

Vitamin A deficiency (VAD) affects people all over the world. The most severely affected individuals are those in countries where access to Vitamin A rich foods such as dark leafy greens and dark red or orange vegetables, along with liver, eggs, and cheeses are not readily available. Vitamin A deficiency most harmfully affects young children, where it is needed for correct development, and pregnant women, where Vitamin A stores are depleted. Several methods have been put into action over the years in severely affected countries to help combat VAD. There are programs to increase the availability of Vitamin A in foods by supplementing or enriching them. Programs to distribute Vitamin A supplements have been also been implemented. Both of these programs work to an extent, but are not completely effective. For bio-fortified foods, the price may be too high to allow access by the very poor, who need it most. In the case of Vitamin A supplements, the return rate of patients to obtain the required supplements is often inadequate, and the cost of providing the supplements is high (1).

A new genetically engineered crop is being developed to help fight VAD in Southeast Asian countries, where the problem is extremely prevalent. Golden Rice, a genetically modified (GM) crop, yields a rice crop that has high levels of beta-carotene, giving it an orange or ‘golden’ color. The beta-carotene is then converted by the human body into Vitamin A. Since rice is a staple in most Southeast Asian countries this means of reducing VAD would reach most of the population. Also by giving the people seed to sow the crop year after year, they will be able to provide for their own needs on a continuing basis (2).

The public response to GM crops is mixed. There is a great movement to ‘go organic’, which involves growing and planting crops that have not been genetically modified as well as not using fertilizers or any pesticide chemicals. There is also a great misunderstanding regarding
the process of creating the GM plants. Some consumers believe that chemicals are used to change the plants genetic material and then these chemicals will harm them when they eat the product.

I have researched the technique used to make Golden Rice, along with the prevalence of VAD. In the remainder of this paper, I will expand on these topics along with the public’s view of GM products. Also I will present my personal opinion on the effectiveness and use of GM crops.

**Vitamin A: Action in the Body**

Vitamin A is a fat-soluble vitamin that is commonly found in the red and orange vegetables, which have high levels of β-carotene, giving it their red and orange color (3). Vitamin A is found in a myriad of different fresh foods. Preformed vitamin A can be found in animal products such as breast milk, meat, liver, fish oils, egg yolks, milk and some other dairy products. Preformed vitamin A is commonly used to fortify processed foods such as cereals, sugar, fats, and oils. Plant sources contain carotenoid compounds that are precursors of Vitamin A (proVitamin A). Carotenoids are found in dark green leafy vegetables such as spinach, amaranth, and kale. They can also be found in yellow or ‘golden’ vegetables such as pumpkins, squash, carrots, and sweet potatoes. Provitamin A carotenoids are found not only in vegetables but also in yellow or ‘golden’ fruits that are not citrus: mangoes, apricots, and papayas. Another common source of these provitamin A carotenoids in some countries is red palm oil (4).

Vitamin A is linked to the health of the body’s epithelial tissue and immune system. Vitamin A itself comes in three forms: as an alcohol, an aldehyde and an acid. The alcohol form of vitamin A is called retinol, the aldehyde is called retinal or retinaldehyde, and the acid form is retinoic acid. These preformed components are found in animal products. Precursors of Vitamin
A found in plants are called carotenoids, in particular, beta-carotene. As beta-carotene is converted in the body through metabolism, Vitamin A is produced. The amount of Vitamin A that is produced from plant carotenoids depends on how efficiently our body absorbs the carotenoids and also how efficiently we convert it. The composition of the plant also affects the availability and ease of conversion in the body. Since vitamin A is a fat-soluble vitamin it needs the presence of fat in order to properly be absorbed (3).

The alcohol form of Vitamin A, retinal, serves as a structural component in the visual pigments of the rod and cone cells located in the retina. This is crucial to photoreception, which allows for processing of an image. Photoreception is the result of light-induced isomerization of 11-cis-retinal to a trans form. Along with its function in photoreception, the retinol form of vitamin A also contributes to normal reproduction, bone development and function, and also proper immune system function (3).

While the role of vitamin A in vision is well understood, the same cannot be said for its systemic function. Vitamin A in the acid form (retinoid acid) may act as a hormone to control gene expression. Inside of the cell, a protein called Cellular Retinoic Acid Binding Protein (CRABP) transports the retinoic acid to the nucleus of the cell. Once there, the retinoic acid along with another related molecule, 9-cis-retinoic acid, binds to retinoic acid receptor proteins and this complex binds to retinoid receptor sequences on a specific gene. This interaction with the gene either inhibits or stimulates the gene transcription process. If the gene is transcribed to form its corresponding messenger RNA, which is then translated into protein, then body process can continue. If transcription is inhibited, then the body processes that are associated with the gene are inhibited. Some of the body processes that are affected are the morphogenesis of embryonic development and epithelial cell function (3).
Another systemic function of vitamin A is in glycoprotein synthesis. In certain reactions the retinol combines with the sugar, mannose, to form retinyl-phosphomannose, which then transfers the mannose to various proteins. The resulting glycoproteins are necessary for normal cell surface function. These functions include cell aggregation and cell recognition (3).

**Vitamin A Deficiency**

VAD can occur in any sex or age of a person, however the most serious and fatal cases are in children under the age of six years old. Blindness that is related to VAD is most prevalent in those with VAD who are three years of age or younger. At this stage of life vitamin A is required in high amounts in order to support the high amount of growth that takes place. At this age the child is also weaned off of either breast milk or formula and will start getting their nutrients from other foods, which may have less Vitamin A than breast milk or formula. This results in the need for an increase in dietary Vitamin A, along with a need to monitor the intake of Vitamin A for possible deficiency. Vitamin A also is involved in reducing the risk of respiratory and gastrointestinal infections (4). It is necessary in order to help with proper eye growth. When deficiency is present blindness, night blindness, or Bitot’s spots can occur. Bitot’s spots are white foamy spots of built-up keratin on the conjunctiva of the eye. When Vitamin A in the diet is low, fat stores become depleted which can lead to xerophthalmia (dry eye) or decreased resistance to infections (1).

Rhodopsin is the chemical that enables us to see in dim light. For example, when you turn off the lights in a room you are able to see because of the production of rhodopsin. Rhodopsin is produced by in the rod cells of the eye. Trans-retinol is converted to retinaldehyde then isomerization changes the retinaldehyde to the 11-cis-form, which then binds to opsin to form rhodopsin. Rhodopsin formation is completely dependent on the amount of retinol that is
available. One of the common signs of decreased levels of retinol in the body is a condition called night blindness, since you are unable to see in the dim light of night. Night blindness however is not only due to the lack of retinol resulting in the inability to produce rhodopsin, it can also occur when there is a deficit of zinc or protein as these minerals are what aid in the formation of rhodopsin (4).

Epithelial cells depend on Vitamin A for growth and differentiation. In Vitamin A deficiency the number goblet cells, cells that secrete mucus, in epithelial tissues are decreased. Since the number of goblet cells is decreased the amount of mucus secreted also decreases. With the mucus secretions come antimicrobial components. Since there is a lower antimicrobial effect the cells lining the protective tissue are unable to grow and regenerate and instead they flatten and keratin accumulates. The decline in antimicrobial mucus secretion and the accumulation of keratin decrease the body’s ability to fight against pathogens. This is how Vitamin A deficiency affects the body’s immune system and ability to fight off infections, which can be detrimental in countries where the Vitamin A availability is low, sanitation is low, and infectious diseases are high (4).

VAD is not clearly defined. The World Health Organization defines it as a level of vitamin A that is low enough to have adverse health effects even if there is no presence of xerophthalmia. The negative health effects besides xerophthalmia could be blindness that may be irreversible, increased morbidity and/or mortality, decreased reproductive capacity, increased risk of anemia, and also decreased growth and development. This usually occurs with blood levels anywhere from 0.35 to 0.70 µmol/L of serum retinol. The problem with these adverse health effects are that they are nonspecific to vitamin A deficiency (besides blindness) and can be caused by a myriad of other vitamin or mineral deficiencies. This is the reason that vitamin A
deficiency is not clearly defined (4).

In 1995, the World Health Organization estimated the global distribution VAD (3). They also ranked countries on the severity of VAD being a health problem based on prevalence of clinical and subclinical effects. The subclinical low levels of vitamin A were measured through blood assays. According to this survey over three million children have xerophthalmia, in addition to this, another 250 million children have low vitamin A serum levels according to blood assays. The region with the highest prevalence was Southeast Asia, which includes countries such as the Philippines, Brunei, Indonesia, and Thailand. Southeast Asia had a prevalence of 1.45 million clinical and 125 million subclinical cases of vitamin A deficiency. The next highest region was Africa with 1.04 million clinical and 52 million subclinical cases. The region with the lowest prevalence was the Americas, (South, North, and Central America). The prevalence in these countries was only 60,000 clinical and only 16 million subclinical cases. Vitamin A deficiency is most common in countries where people consume most of their vitamin A from carotenoid sources and also whose diet is low in dietary fat. Different sources of Vitamin A allow for different amounts of rates of converting carotenoids into Vitamin A (see Table I) (5).

**Table I: Comparison of Pro-vitamin A Carotenoids Conversion Factors (5)**

<table>
<thead>
<tr>
<th>Food Contributing Vitamin A</th>
<th>Conversion Factor for Pro-vitamin A Carotenoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit</td>
<td>12:1</td>
</tr>
<tr>
<td>Sweet Potato</td>
<td>13:1</td>
</tr>
<tr>
<td>Carrot</td>
<td>15:1</td>
</tr>
<tr>
<td>Dark Leafy Green Vegetables</td>
<td>10:1</td>
</tr>
<tr>
<td>Golden Rice</td>
<td>3.8 ± 1.7:1</td>
</tr>
</tbody>
</table>

About 90% of ingested preformed Vitamin A is absorbed by the body, this amount can vary based on the food source that is being eaten along with the fat that is included in the meal,
as fat is necessary for the absorption of Vitamin A (Vitamin A is a fat soluble vitamin). In the countries where VAD is most prevalent the main source of Vitamin A is vegetables. These vegetables contribute about 80% of the retinol equivalents to the population. In Southeast Asia particularly, the availability of vegetables providing retinol equivalents is low. Furthermore the availability of Vitamin A rich animal products (egg, liver, milk) are also scarce. The availability of Vitamin A from animal sources in Southeast Asia is 52 µg Retinol Equivalents/day (RE/day), while from plant sources it is 378µg RE/day (4). When compared to the Dietary Reference Intakes (DRIs) listed in Table II the supply is greatly lacking.

Table II: DRIs for Vitamin A According to Life Stage (3)

<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Vitamin A DRIs (µg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants (0-12 months)</td>
<td>600</td>
</tr>
<tr>
<td>Children (1-3 years)</td>
<td>600</td>
</tr>
<tr>
<td>(4-8 years)</td>
<td>900</td>
</tr>
<tr>
<td>Males &amp; Females (9-13 years)</td>
<td>1700</td>
</tr>
<tr>
<td>(14-18 years)</td>
<td>2800</td>
</tr>
<tr>
<td>(19-70 years)</td>
<td>3000</td>
</tr>
<tr>
<td>(&gt;70 years)</td>
<td>3000</td>
</tr>
<tr>
<td>Pregnant Women (≤ 18 years)</td>
<td>2800</td>
</tr>
<tr>
<td>(19-50 years)</td>
<td>3000</td>
</tr>
<tr>
<td>Lactating (≤ 18 years)</td>
<td>2800</td>
</tr>
<tr>
<td>(19-50 years)</td>
<td>3000</td>
</tr>
</tbody>
</table>
Strategies to Reduce VAD

Experts believe that the best long-term way of supplying increased Vitamin A is to encourage people to eat diverse foods that are naturally high in it, or in Vitamin A sources. However, this is not possible in many countries where the people who need help the most (the extremely poor and most remote from supplies of these foods) (6).

Another way of providing sufficient levels of Vitamin A to people who do not receive enough of it is for governments to supply Vitamin A as free supplements. It has been shown that supplements can be helpful in decreasing health problems connected with VAD. For example, in a research study published in Lancet (7), children in Nepal were given Vitamin A supplements and the changes in morbidity due to common infections were recorded. A total of 28,630 children participated in this study, ranging in age from 6-72 months. In this study, half of the children received 60,000 equivalents of retinol every four months and the other received a placebo that contained only 300 retinol equivalents every four months. The study lasted 12 months. The researchers observed a 30% decrease in childhood mortality due to common infections, which cause diarrhea and dysentery. This decrease correlates with the action of Vitamin A to assure proper functioning of the immune system. The overall suggestion from this study was that periodic Vitamin A supplementation would be helpful in decreasing childhood mortality in those countries where there may be lack of access to Vitamin A rich foods. The researchers concluded that,

“Periodic dosing should not preclude, or compete with, efforts to improve the local food supply and dietary vitamin A intake by vulnerable groups (e.g., by means of gardens, dietary counseling, and fortification) (7).”

They also stated that an increase in frequency of supplementation might decrease mortality even
Administering Vitamin A supplements in high doses has been proven to control xerophthalmia, and decrease childhood blindness along with decreasing the mortality rate linked to infections such as the measles and diarrhea (8). While administering Vitamin A or retinol supplements to those who are at risk seems like a quick fix, the main problem with this method is to assure return visits. In many of the countries where the supplements are needed the people may need to travel a long way to get to the medical site. This could pose a problem for mothers who are in charge of taking care of many children. Creating the feeling of necessity in those patients who are at risk or those who are caretakers of at risk patients is another obstacle that needs to be addressed. If the people do not see or understand the connection of getting a supplement every month or even every four months, they will have little motivation to come to subsequent appointments for supplementation. If we are able to raise awareness of the effects of Vitamin A deficiency, or even just what Vitamin A is and what it does to help your body it may help raise a sense of urgency when planning to administer these supplements. Ideally it would be best to show at risk population the benefits of periodic supplementation. While supplementation is a good idea, the method of administration would have to change for it to be 100% effective, and even then, many people in these different countries from different cultures may not accept the idea of putting a supplement into their bodies if they are not comfortable or knowledgeable about what it will do to their bodies (1).

Another way of providing increased Vitamin A is to add vitamin A to foods. This method is called food fortification. However, this method requires a significant capacity to process foods with these additives (6). Therefore, this method can be expensive and might be out of the reach of many poor countries.
A fourth method, called bio-fortification, is to change foods that are typically eaten in large amounts (staple foods) but are normally low Vitamin A or Vitamin A sources, and to increase the levels of this nutrient (6). Because this method requires changing these staple foods to do something that they do not normally do, it may be necessary to genetically modify them. The process for making these genetic changes is explained further in this paper. This method can also be another tool to reduce VAD, and is being developed as a way of supplementing the other strategies described previously. It will have the advantage of being provided only a few times to Vitamin A deficient people, and allowing them to grow their own sources of food on a continuing basis. Therefore, they will be able to provide themselves with a low cost source of Vitamin A.

At this point, genetically modified bio fortified foods have not yet reached the general public. However, research has already been done to show that it can be a good source of carotenoids that the human body converts into Vitamin A. This research was done with genetically engineered rice that produces high levels of beta-carotene, called Golden Rice. In a study published in The American Journal of Clinical Nutrition, Tang and her colleagues investigated the effectiveness of Golden Rice in acting as a source of Vitamin A. In this study Golden Rice plants were grown in a hydroponic setting in water that had deuterium oxide (heavy water) in it. The effect of the deuterium oxide on the resulting rice was that the β-carotene would be labeled with the deuterium. A total of five volunteers served as the subjects in this study. The volunteer group was comprised of two men and three women that were in good health and all were from the Boston, Massachusetts area. The ages of participants ranged from 41-70 years old with BMI’s ranging from 22-29. All were non-smokers. The study lasted for 36 days in order that the vitamin A status found in the blood would be enough to show up on blood tests
and response curves (5).

On the first day of the trial the participants consumed .99 mg of retinyl acetate (a source of Vitamin A) in an oil capsule. This dose was used as a reference dose for the rest of the study. The amount for the reference dose was decided after the use of .43 mg of retinyl acetate did not appear adequate for detection in all volunteers (i.e. Those with a higher body mass). The retinyl acetate oil capsules were given with 200g of cooked regular white rice, 10mg of butter, 50g of peeled cucumber, 0.2 g salt, 5g vinegar and 500mL of bottled water for the breakfast meal; a total of approximate 450 kcal with 23% of the kcal coming from fat. A second meal (lunch) was offered four hours after breakfast. This meal was comprised of 60g of turkey meat, 50g white bread, 20g roasted cashew, and 100g of peeled cucumber salad (15g corn oil, 5g vinegar, and cucumber); this meal totaled out to be 600 kcal with 40% of those kcals coming from fat. On day eight of the study the participants ate the same breakfast meal, but the cooked white rice was substituted with the deuterium labeled golden rice. The amount served was either 130g of cooked Golden Rice along with 70g cooked white rice that contained 0.99 mg β-carotene or 200g cooked Golden Rice containing 1.53mg β-carotene. The type of rice varied due to the aim to study as many subjects as possible while limiting the amount of deuterium labeled rice. On day eight the previously mentioned second meal (lunch) was also consumed four hours after the breakfast meal as normal (5).

To assess the serum levels of vitamin A, a total of 30 samples of 10mL of blood were taken from each subject. These were taken on day one just before breakfast, and then 5, 8, 11, and 13 hours post meal. On day two they were taken just before breakfast and 5, and 11 hours post meal. Day three samples were obtained just before breakfast and 11 hours after breakfast. On days four, six and seven samples were taken just before breakfast was served, and on day
eight samples were obtained just before breakfast, and 5, 8, and 11 hours after breakfast was
eaten. Day 9 before breakfast and 5 and 11 hours after, day 10 before breakfast and 11 hours
after. On days 11, 13, 15, 19, 22, 29, and 36 samples were taken only before breakfast was
served. From these samples the retinyl acetate, retinol from deuterium labeled Golden Rice β-
carotene, and intact Golden Rice β- carotene were recorded (5).

For the Golden Rice β-carotene the analysis of the serum samples through liquid
chromatography showed that the participants absorbed the deuterium labeled β-carotene intact.
After receiving a reference dose on day 1 and a 0.99 or 1.53 mg labeled Golden Rice dose on day
8, the study participants’ mean retinol equivalent level in blood serum was 0.36mg. This is quite
significant because the 1.53mg Golden Rice consumed yields anywhere from 0.24-0.94mg
retinol and the 0.99mg Golden Rice yielding anywhere from 0.24-0.51mg retinol. Using these
figures to estimate the amount of retinol yield for the amount of Golden Rice consumed by
participants, the conversion factor for β- carotene to retinol is 3.8 ± 1.7 to 1 by weight, which is
the mean ± SD. When compared to the conversion ratios of other vitamin A contributing foods
(Table I) Golden Rice has quite a positive conversion factor and therefore is a promising source
of vitamin A (5).

**How is A Genetically Modified Crop Produced?**

How is a genetically GM crop made? Just as the name suggests the crop is made by
changing, or modifying, the genes of the crop. Eufemio T. Rasco Jr. explains how a GMO is
made by using the four steps similar to those that a civil engineer would use: The design phase,
the parts production phase, the product assembly phase, and the product testing phase. In the
design phase the engineer must determine the main objective for the project and also must
identify what tools are going to be needed to successfully attain her objective. This is essentially
the planning stage where a plan of action is drawn up. The gene used to modify the plant is derived from another plant, or any other organism, such as a bacterium. The engineer will study different genes and determine what genes are to be changed and how, in order to achieve a desired trait, such as the ability to repel an insect pest or produce more of a certain nutrient. One important part to this step is making sure that there is a viable market or use for the finished product. For example: soybeans, corn, cotton and canola are the crops that are commonly produced using genetic engineering methods. They are produced as commercial crops and used commonly for feed for cattle, to extract oils, or to make into fiber. As stated previously, in this stage the engineer must find the gene necessary to give the crop the specific trait that was defined in the objective (9).

One method for isolating a gene is to use mRNA hybridization. In this method, the engineer might want to take a protein from a bacterium and create a plant that makes that protein. She can then isolate the mRNA that is used by the bacterium to make the protein. This mRNA is a single stranded molecule and is then used as a template for making two-stranded mRNA-DNA hybrids by using an enzyme called reverse transcriptase. The single strand of DNA is then extracted from the mRNA-DNA hybrids, and is then used as a template to make the complementary strand of a complete double-stranded DNA molecule. As a result, the gene that makes the mRNA, which in turn makes the protein, is reconstructed. The DNA can also be run through a DNA sequencing machine in order to determine its nucleotide sequence. (9).

In the next step, the parts production phase, the gene that is to be inserted into the crop is assembled with other DNA pieces that will allow the gene to work in a plant. The most important pieces are called the promoter and the terminator. The promoter sequence is located at the 5’ end (the beginning) of the gene and determines when, and in which tissues, the gene will
be expressed. The promoter also controls how active the gene is. The terminator is found at the end of the gene and marks where the sequence of the gene stops. In order to paste these pieces together an enzyme called DNA ligase is used (9).

In the third step, the product assembly phase, the gene is inserted into cells of the plant that is to be modified, and a GM plant is regenerated from those cells. The gene that was constructed in the first two steps is placed into specific bacterium, *Agrobacterium tumefaciens*, which has a natural ability to transfer genes to a plant. Pieces of plant tissue are then mixed with the *Agrobacterium*, and the transfer process happens. The plant tissue is then removed and cultured in a medium that kills the *Agrobacterium* but allows the plant cells to grow, divide, and eventually form a new plant. The new plant is then grown, and the seeds from that plant collected for observation. The mature plants that have been modified are then allowed to produce seeds so that more plants can be made (9).

The final stage, the product-testing phase, is the time where the resulting plants are tested for how well the transferred gene causes the intended new trait to be observed in them. If the plant is supposed to repel to a certain type of insect, then the plant will be subjected to an environment with the insects and if the plant does not get damaged, then the right trait has been observed. If the plant is supposed to produce more of a certain type of nutrient, such as increased pro-Vitamin A (beta carotene) in rice, then the color of the rice grain will turn a yellow color. If the right trait is observed in the plant, then the plant can be multiplied many times by seeds or cuttings until there is enough for farmers to grow (9).

**How Was Golden Rice Created?**

Using the methods explained in the previous paragraphs, Golden Rice was created by inserting two genes into rice. One is from corn, while the other is from the bacterium, *Erwinia*
The gene from corn causes the rice to produce an enzyme called phytoene synthase (PSY), while the gene from *Erwinia* causes the rice to produce an enzyme called phytoene desaturase (CRTI). These two enzymes are needed to convert carotenoid compounds in developing rice grain into beta-carotene. They are not normally found in rice grain, but when these two genes are added, the rice develops a yellow (or “golden”) color (10).

**Interviews to Assess Public Awareness**

I was curious to find out what some of the people around me knew about GM crops. To get a sense of this, I interviewed two people from various educational and social backgrounds. While this was in no way a controlled experiment or survey I still think it gives an overview of the opinions of those who are for and those who are against the use of GM crops. For each interview I asked the same base three questions and then let the interviewee continue on with any other information or opinions that they had on the subject.

Caroline Webber, RD, PhD, was interviewed on April 4, 2012. She is an active member in the Hunger and Environmental Nutrition Dietetics Practice Group (HEND). Dr. Webber received her bachelors in science degree from University of California- Berkeley and her PhD from Cornell University. The first question asked was, “To the best of your knowledge, can you explain to me how genetically modified crops are made?” Dr. Webber replied that she was not an expert but she had a general idea. She described that genetic modification could be done across species. She also described that what she heard from a colleague of hers that worked personally in a lab working with genetically modified organisms (GMO) that, “it is sort of a hit or miss procedure (11).” When I asked about her general opinion on the use of GM crops she responded by saying, “My first opinion is that it is unnatural, however, just because something is unnatural doesn’t mean it isn’t good (11).” Dr. Webber has some concerns with the use of GM crops. She
did not seem to support the use of it very much, as she was very cautious when it came to applications due to the unknown consequences that may take place. One concern she voiced was that of the safety when growing crops in the field. She mentioned that she did not know if this was still relevant but the fact that they produce GM crops in a field that is next to non GM crops may produce some cross contamination between the two. She was worried that the seed from the GM crops may combine with that of others and create some other crop that was not intended and may have negative effects. Being a professor in the dietetics major she also expressed concern that there may be food allergies that are related with GM crops due to the foods that the genes are taken from. She did mention that because GM foods do not yet have to be labeled in the United States that there is no way for those with a gluten allergy, celiac disease, peanut allergy, soy allergy or other common food allergies to know what kind of food went into the crop that was created. Dr. Webber was then asked about her ideas of GM crops when there is a humanitarian aspect connected with it, such as in the case of Golden Rice. I briefly explained the idea and need for Golden Rice to give her a better background on the problem with vitamin A deficiency in low-income countries. With the added aspect of humanitarian benefit to the equation her opinions did not seem to change much. She did suggest that instead of jumping to a solution that looks glamorous and makes people money why could we not try and fix the underlying problems that inhibit the people of these countries from accessing the necessary foods; whether economic, political, or environmental. She also expressed concern that the changing of the type of rice that was traditionally grown and eaten in these countries would change the meaning and significance of the heritage of the rice paddies. There was concern about the possible change in flavor that would change the traditional use of rice as a staple grain in these South Asian countries. When asked if she was aware of what foods on the market were
commonly GM crop she mentioned a few well known crops; soy corn, and then mentioned the FlavrSavr (a GM tomato that was commonly grown initially but is no longer grown for food). She stated that she gets most of her information from word of mouth, HEND, nutritionists that she worked with at Cornell or an Internet newsletter called Hot Topics (11).

Based on Dr. Webber’s interview I can see a few misconceptions that someone who does not research GM crops can make. Dr. Webber is a very well educated individual, as reflected in her credentials, but GM crops are not her field of study. One of the concerns people may have is similar to that of Dr. Webber’s when she stated the problem of not labeling GM foods as they may carry common food allergens due to crossing species. As of right now in the United States a GM food product is not required to be labeled, although the push for this to be done is growing momentum with the organic food trend. This is a valid point of concern, however, GM undergo very rigorous testing to make certain that there are not any proteins that may cause allergic reactions (12). I believe that there is not enough awareness of the rigorous testing that these crops undergo in order to be approved for human use. The fact that they are not aware of the tests required could cause some anxiety about how safe the product is for consumption. There are three guidelines (41-43) that deal specifically with the testing for food allergies that are stated in the Codex Guidelines for the Conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Plants:

41. When the protein(s) resulting from the inserted gene is present in the food, it should be assessed for potential allergenicity in all cases. An integrated, stepwise, case-by-case approach used in the assessment of the potential allergenicity of the newly expressed protein(s) should rely upon various criteria used in combination (since no single criterion is sufficiently predictive on either allergenicity or non-allergenicity). As noted in
paragraph 20, the data should be obtained using sound scientific methods. A detailed presentation of issues to be considered can be found in Annex 1 to this document.

42. The newly expressed proteins in foods derived from recombinant-DNA plants should be evaluated for any possible role in the elicitation of gluten-sensitive enteropathy, if the introduced genetic material is obtained from wheat, rye, barley, oats, or related cereal grains.

43. The transfer of genes from commonly allergenic foods and from foods known to elicit gluten-sensitive enteropathy in sensitive individuals should be avoided unless it is documented that the transferred gene does not code for an allergen or for a protein involved in gluten-sensitive enteropathy (12)

In guidelines 42 and 43 the issue of gluten allergy or celiac disease is addressed, which for practicing dietitians is a big concern as it is very hard to follow a gluten free diet given all of the additives to most foods on the market (12).

The idea of fixing the problems; economic, political, or environmental, that keep these countries from either growing or accessing Vitamin A rich foods was a very interesting point raised in the interview (11). While I do agree that in the long run it would be better to provide an economic, political, and environmental solution; this does not help those suffering right now, and an environmental solution may not be possible. A permanent solution for increasing Vitamin A in the diet would be to increase the access to dark leafy greens (common source of Vitamin A) or other foods commonly rich in Vitamin A sources. However, as I mentioned above, diverse diets may be too expensive and not available to many extremely poor populations. Another solution is to incorporate these leafy greens into traditional meals. However, doing this might be difficult because of people’s loyalty to traditional dishes or meals. If there is a new ingredient added to
how these foods are made, they are no longer traditional. It also may be difficult to introduce foods that are not commonly eaten or seen in a country’s every day diet. Most people resist change, especially in something as basic as food.

My second interview was with a Western Michigan University senior who also holds a job as a meat and cheese buyer at Kalamazoo’s Peoples Food Co-op, Nicole Hall. She was given the same questions as Dr. Webber. Nicole is an advocate for the use of GM crops, but under certain circumstances. She thinks that while the idea of GM crops to help improve the diets of consumers is great, but the fact that someone can claim intellectual property on the GM crops is the big downfall of the GM crop process. When companies who manufacture GM crop seeds claim intellectual property, it keeps the farmers from saving seeds from their harvest, to then plant the next year as would be traditionally done. Instead the farmers are required to buy new seed every season. When asked what she knows about how GM crops are made, she explained that it was a combination of splicing genes from one species or organism, and inserting it into another’s genetic code. Her main concern, besides that of big companies claiming intellectual property, is that it seemed to be a lot of guessing when putting genes together. With all of the guessing she was concerned that the outcomes are never positively known and therefore we could get something that ends up to be harmful. She expressed the belief that the use of GM crops is appropriate in developing nations that do not have access to necessary foods or health supplements. However, she does not think that they have any place in developed countries where the food supply and variety is great. When asked what GM crops she knew of that were on the market, she responded that she knew that major cash crops for the United States were GM crops such as corn and soybeans. Nicole gets her information on GMOs and GM crops from her college classes, documentaries, internet resources, and listening to other’s opinions (13).
I agree somewhat with Nicole’s view of only using GM crops in those instances where it is necessary. In the United States a crop like Golden Rice is not necessary since there is great access to vitamin A rich foods along with vitamin A supplements and even dietitians that can help people incorporate foods into their diet, or help them plan a healthy diet. In countries, such as the Philippines, where the food supply is not constant for the impoverished population, I feel that the use of enriched GM crops is a very sustainable solution to the deficiencies found in these countries. In these countries the access to healthcare and supplement programs is significantly less than in the United States. For example, in the Philippines there were only 1.2 physicians per 1000 people whereas in the US there are 2.7 physicians per 1000 people in 2009 (14). On the other hand, I do not agree with Nicole that this is the only geography where GM crops should be grown, but that they should be utilized to their full potential. I also feel that the use of certain pest resistant plants are something that we need to put into practice in the US and in other countries, developed or not, in order to receive a larger yield per harvest. I do not see anything wrong with using GM plants that naturally, through genetic changes, repel the insects or diseases that cause it to die (13).

Academy of Nutrition and Dietetics Stance on Genetically Modified Crops

The Academy of Nutrition and Dietetics (AND), formerly American Dietetic Association (ADA), published their position on GM crops in 1995 and reaffirmed it in 1998. In the AND’s position paper they approve of the use and research of GM crops as a tool to increase the availability and nutritional content of food as well as enhance food growth and processing. They encourage nutrition professionals to raise awareness of the process of GM crops as well as their use to the public. In their position paper they mention Golden Rice and other Vitamin A fortified crops as a way to increase the consumption of Vitamin A. It is recognized by the AND that GM
crops can have a positive effect in many aspects,

These nutritionally enhanced crops have the potential to lessen nutrient deficiencies; improve the nutritional value of food and feed; promote well being through elevated levels of beneficial compounds; lower levels of natural toxins, toxic metabolites, or allergens; improve processing; and enhance taste (15).

As a future dietitian I must recognize the nutritional benefits that these crops can have, not only through fortification, but also through the decreased expression of allergenic proteins in wheat and lower levels of trans-fatty acids in vegetable oils (15). Coming from this viewpoint I believe that it is important for nutrition educators and registered dietitians to support the research of GM crops as they can be and will be very useful in the future of nutrition.

Conclusion

Vitamin A deficiency can affect proper growth, immunity, and result in permanent or night blindness. Adequate levels of Vitamin A is most important in young children and also pregnant women due to its affect on proper growth (2, 6). Golden Rice, a rice that has been genetically changed to yield higher amounts of Vitamin A, is a new GM crop that has been introduced in order to help decrease the amount of VAD in developing countries and the affects that VAD has on the people (1). While there is controversy over the usage of GM crops, it has been proven that Golden Rice can be a great addition to the Southeast Asian countries that show high prevalence of Vitamin A deficiency (VAD). The introduction of Golden Rice along with supplementation programs and continuing an attempt at increasing access to Vitamin A rich foods will help with the decreasing of VAD in these countries (6,7). Through two interviews that were performed it can be noted that the reception of GM crops and products has an overall negative connotation that can affect the opinions of even educated individuals (11, 12). I believe
that GM crops when used in the correct situation, in developing countries, can help not only in instances such as that discussed in this paper with VAD, but also through helping decrease the amount of crops that die due to drought or insect infestation which can increase the yield, which in turn increases the amount of food available to feed the people. As a future registered dietitian I believe that it is important to support the use and development of GM crops, as it can be a great help in our field of work. The work that has already been done with fortifying crops, decreasing allergenic protein expression, and also reducing the amount of trans fatty acids in vegetable oil; are advancement that could change the way that we counsel clients (15).
References


