The False Promise of Genetically Engineered Rice

"Genetically engineered (GE) rice --such as the now-famous Vitamin A rice or 'Golden Rice'-- is being heavily promoted as a solution to hunger and malnutrition. Yet these promotional campaigns are clouding the real issues of poverty and control over resources, and serving to fast-track acceptance of genetically engineered crops in developing countries. (…) Vitamin A rice is a techno-fix to the problems of the poor decided upon and developed, without consultation, by scientists and experts from the North."
Joint statement to the press, 2 June 2000, by three farmer organisations from Southeast Asia. [1]

News about a "Golden Rice" first appeared in August 1999, when scientists announced they had succeeded in genetically engineering a rice variety to contain Beta-Carotene (or pro-Vitamin A), a compound that our body can convert into Vitamin A.
The scientists said they hope that this genetically engineered (GE) rice would be an important tool to fight Vitamin A Deficiency (VAD), a malnutrition problem which affects millions of people in poor countries, especially children and pregnant women.
GE rice has been presented in some publications and debates as a quick and easy solution to VAD, but evidence shows that this is not the case. In the short term GE rice is the most expensive, least developed, and most ecologically dangerous way to address VAD. In the long term, the single-crop approach of GE rice may be a serious threat to food security.

The biotech industry is using this rice to gain public acceptability for GE foods. Biotech companies argue that their patented crops are needed to feed the world, but this is a fundamentally flawed claim based on the false assumption that hunger exists because of a gap between food production and human population.
In fact, "The world produces enough food to feed all the people who inhabit it - and it could produce even more," according to United Nations Food and Agriculture Organisation (FAO) head, Jacques Diouf.[2]
FAO's recent food security assessment "Agriculture: Towards 2015/30" excludes genetically modified organisms yet concludes that food production will continue to increase over the period to 2030 and will continue to exceed population growth.[3]
This report confirms that the real causes of hunger and malnutrition are poverty and lack of access to food, issues that GE rice does not address. It is also noteworthy that seventy-eight percent of all malnourished children in the developing world live in countries with food surpluses.[4]

"(…) Seeking a technological food fix for world hunger may be not only the biggest scientific controversy of 1999, but also the most commercially malevolent wild goose chase of the new century. (…) The little research that has been conducted about the origins of famine reveals that the solution of "more food" may be no solution at all."
Dr Richard Horton, editor of the British science journal *The Lancet* [5]

According to its developers, GE rice could be available for local planting in 2004 at the earliest. However, this estimate would not leave sufficient time to assess its local socio-economic, health and environmental impacts.
Since a variety of measures addressing the problem of Vitamin A Deficiency exist today, VAD could potentially be eradicated through existing solutions even before such GE rice evaluations reached an advanced stage. The problem is political will, not lack of solutions.

Focusing on existing short and long term strategies would address the real issues of malnutrition while avoiding the problems associated with GE rice. These problems include not only technical, nutritional and environmental risks, but also corporate patents, unintended health effects and consumer acceptance.

PART I. **The problems of GE rice**

'WHO has not received specific documentation relating to the genetic modification of Vitamin A rice, nor information relating to the safety testing of this product…It should be noted that the following items need to be considered in a broader evaluation:…health side-effects, if any, are unknown: health tests have to be conducted; the bioavailability of carotenoids included in the GM rice is unknown (digestibility in particular); consumer acceptability also needs to be investigated as the GM rice have a yellow colour'.
Jorgen Schlundt, World Health Organisation (WHO), Food Safety Programme[6]

1- Health and nutritional problems:

"A single nutrient approach towards a nutrition-related public health problem is usually, with the exception of perhaps iodine or selenium deficiencies, neither feasible nor desirable."
John R. Lupien, FAO, Director of the Food and Nutrition Division[7]

GE rice is intended to replace existing rice varieties and, if successfully introduced, it will be eaten in large quantities and might become the only staple food accessible to many.
Nevertheless, as yet no health safety tests have been carried out on Vitamin A rice in any region. The health safety assessment will need to be rigorous and may become a true challenge, as it will have to ensure that no new allergenic properties[8] or other unintended metabolic changes [9] are introduced.

In addition, the uptake and absorption of Pro-Vitamin A depends on many factors, including adequate intake of proteins, vitamin E, zinc, and fats. Pro Vitamin A has to be built up to Vitamin A in the body and this process only works in the presence of fat or oil. But poor people's diets often lack fat and other key nutrients so the Pro-Vitamin A available from GE rice could be excreted undigested by many.

For many groups in Asia, GE rice is disconnected from the causes of malnutrition at ground level. Farmers' own experiences of diversification show that there are many ways to address vitamin A deficiency in Asia without isolating the problem from socio-political realities. For example, encouraging the reintroduction of locally grown varieties of vegetables rich in micronutrients, including Pro-Vitamin A, has been successful in Bangladesh and Thailand.[10]

It should be pointed out that the industrial model of agriculture is seen by many as a reason for malnutrition and the lack of a diverse diet. (See *Appendix B: Vitamin A Deficiency*).
According to the non-profit foundation Genetic Resources Action International (GRAIN), “The Green Revolution paradigm of market driven, industrial agriculture that genetic engineering is an extension of, has reduced agricultural biodiversity, and, as a result, dietary diversity, thus increasing micronutrient malnutrition among the poor."

"The tragedy is that the local varieties this model of agriculture destroys are an excellent source of not only vitamin A but also a whole host of other nutrients, in the very countries that suffer from malnutrition. Dietary diversification would provide a sustainable, equitable solution to malnutrition.”[11]

2- Patents on Vitamin A rice:

> *"Like other academic scientists, [Vit. A Rice inventor] Potrykus was allowed to use patented technology in his research without fear of being sued. That's common practice. But releasing the rice into international commerce is a more serious step, one more likely to raise objections from patent holders"*
> **The Washington Post, August 4, 2000**[12]

In May 2000, GE rice inventors announced a deal under which AstraZeneca -- a UK-based international pharmaceuticals and biotech group with (1999 pro forma) sales of $18.5 billion[13] -- will license and distribute the crop. [14]

Despite the fact that it was presented as an "agreement [which] should help assure that 'Golden Rice' reaches those people it can help most as quickly as possible"[15], the deal clearly has a commercial base.

The multinational company announced it intends to sell GE rice commercially while allowing free distribution and use only to those farmers in developing countries whose yearly profit is lower than a specific ceiling. It is unclear if the announcement is legally binding or if AstraZeneca may still modify the final agreement.[16]

The Peasant Movement of the Philippines (KMP), in a June 2000 statement to the press, asked: "Why should anyone believe that this is for the poor when Zeneca[17] has made it clear that their motive is to make money from the technology in the North?"[18]

It should be noted that Vitamin A rice research was financed by public funds (See *Appendix A: Genetically Engineered Vitamin A Rice*).

A principal concern of GE rice is that it is patented by northern companies that do not allow GE seeds to be saved like traditional seeds. Farmers are required to buy new GE seed each year. But in the developing world, most household farms rely upon saved seed for the next year's crop. [19]

The problem is more complex in this case because the GE rice inventors used a series of patents held by private companies, and "as many as 32 companies and institutions hold 70 patents that cover technologies used in the creation of golden rice," according to the Washington Post.[20]

Legally binding deals with all these patent holders have to be arranged in order to prevent them from claiming licences to the patents. Such claims may make GE rice much more expensive than expected.

3- Technical problems:

> *"We must recognize that our knowledge of the processes that regulate gene incorporation and expression are in their infancy and that our capacity to manipulate the plant genome is crude."*
> **Patrick Brown, Professor, College of Agriculture & Environmental Science, University of California**[21]

Only a few grains of GE rice exist in the lab and no field tests have been carried out to assess the performance and stability of the genetic construct when combined with other rice varieties.

It is a common observation that transgenic plants, while they may perform well in laboratories, fail in nature, especially if -like GE rice- they contain not one but three added gene-constructs.

Documented failures include Monsanto's GE soy. This crop, called Roundup Ready soy, showed splitting stems and up to 40 percent yield reduction under growth conditions with high soil temperatures.[22]

Another example of unexpected problems came from GE herbicide-tolerant tobacco plants when many of these GE plants did not survive spraying with the herbicide in the field after surviving the spraying in the greenhouse.[23]

4-Environmental impact of GE rice:

> *"IRRI's promotion of heavy herbicide use in rice farming wiped out the native green vegetables that are the poor people's sources of vitamin A, and the fish, frogs, shells and crickets that provide the 50 million rural poor with protein, and now [Filipino] people have to spend more of their shrinking incomes on costly food."*
> **Rafael Mariano, Filipino Peasant farmers union chair (Kilusang Magbubukid ng Pilipinas)** [24]

According to the International Rice Research Institute (IRRI), "Given the occurrence and environmental persistence of hybrids between cultivated and wild or weedy rices, the extensive amount of land that may eventually be planted to transgenic rice, and the large populations of wild and weedy rices in many rice growing areas, it must be assumed that transgenes will escape to wild and weedy relatives."[25]

It is unclear if Vitamin A rice would attract more pests because of its nutritional trait. But it must be assumed that its transgenes will escape into the environment [26] with unknown consequences.
Large scale growing of GE rice could lead to massive gene flow to wild and other locally unique varieties of rice and could contribute to the already alarming genetic uniformity of rice in Asia --and its negative impact on food security.
In Asia, where rice is the major staple, "a dark cloud of genetic uniformity is already gripping Asian fields today with production being confined to only a few varieties," the Filipino group MASIPAG (Farmer-Scientist Partnership for Development) warned recently.[27]
"This is a very dangerous situation for farmers and food security since it increases dependence on toxic chemicals and genetic engineers to help defend crops against inherent weaknesses of biological uniformity." [28]
In the words of Devinder Sharma, President of the New Delhi-based Forum for Biotechnology & Food Security, "the golden rice in question is an ecological and health hazard. Nor is it the answer to the nutritional needs of the small producers and poverty-stricken masses in the south. "
"If you can't help the poor in the south, please do not add to their multitude of existing problems, " wrote Sharma in a recent letter to the editor published in the Financial Times. [29]

5- Acceptance of a yellow rice:

It is generally acknowledged that the introduction of a yellow-coloured rice could pose considerable acceptance problems with consumers and farmers. It could easily be stigmatised as the rice for the poor while the rich continue to eat the white rice.
Ensuring acceptance would require massive and locally adapted educational and marketing campaigns in order to change consumer habits, especially those of poor farmers and poor urban populations – those most affected by VAD..
Development agencies, governments and NGOs presently working on VAD would have to be involved in these future efforts, and would be further distracted from effective programmes.
The huge sums needed for such campaigns on Vitamin A rice could have a much broader and lasting effect on malnutrition if they were spent on diet diversification programmes.

PART II. **The on-going fight against Vitamin A Deficiency (VAD)**

When explaining why Vitamin A Deficiency has not yet been eradicated, agencies that are involved in the battle against micronutrient deficiencies -- such as the World Health Organisation (WHO) -- most often mention the lack of political commitment and of funding for existing solutions.

According to the WHO, eradicating VAD "is therefore a test case of political will, and managerial capacity to implement known technologies and known solutions."[30]
Short term and interim measures, such as fortification of food and administration of Vitamin A supplements, are available at minimal costs and are underway in some 80 countries world-wide. Long term solutions based on access to a diverse and Vitamin A-rich diet exist too.[31]
Vitamin A Deficiency is a major cause of total blindness and night blindness, and it also exacerbates the effects of measles, tuberculosis, diarrhoea and other illnesses.

The World Health Organisation estimates that up to 230 million children, mainly in Asia and Africa, are at risk of clinical or sub-clinical VAD and that over one million VAD-related deaths occur each year. Eliminating Vitamin A Deficiency could reduce childhood mortality by 25%.
To date, it is estimated that Vitamin A deficiency is a public health problem in 96 countries, 83 of which have reported data to the World Health Organisation. Africa and South-East Asia have the highest numbers of clinically affected.[32]

The elimination of VAD and all its consequences, including blindness, was adopted as a goal for the end of the year 2000 by the 1990 World Summit for Children and reiterated by the International Conference on Nutrition in 1992.
Progress has been made to this end. The WHO reports that the number of young children with total blindness has fallen by about two-thirds in the past 20 years.[33] UNICEF estimates that there was a 40 percent decline in VAD prevalence between 1988 and 1998[34].
Examples of successful VAD reduction and eradication, in particular in the case of acute clinical VAD, seem to confirm this progress. Some countries, including Indonesia, Vietnam and the Philippines, have virtually eliminated total blindness over recent years.

According to the WHO, governments of 30 countries where VAD signs are strong have not implemented comprehensive plans to solve the problem and in some cases they have not even evaluated the extent of the problem.
Some countries started national programmes to fight VAD only recently and the situation in many sub-Saharan countries appears alarming. It should be noted that war, displacement and natural catastrophes frequently create malnutrition crises of all kinds.
The World Bank estimates that supplementation and fortification interventions to prevent the three most prevalent micronutrient deficiencies (iron, iodine and vitamin A) can be done at a total cost of 1 US Dollar per person a year. Costs for a delivery of a single capsule of vitamin A can be as low as 2 Cents of a Dollar when added to other immunisation efforts.
The World Bank also says that economic and social payoffs from micronutrient programs reach as high as 84 times the program costs and concludes that "Few other development programs offer such high social and economic payoffs." [35] This means that existing solutions are effective and worth investing in now.

CONCLUSIONS

** Genetically Engineered rice does not address the underlying causes of VAD, which are mainly poverty and lack of access to a more diverse diet. This rice is an untested and superficial technological fix that may generate new problems.*

** Vitamin A rice could, if introduced on a large scale, exacerbate malnutrition and ultimately undermine food security because it encourages a diet based on one staple rather than the re-introduction of the many vitamin-rich food plants that were once cheap and readily available. These plants would address a wide variety of micronutriet deficiencies, not just VAD.*

** Cheap and effective means of combating Vitamin A Deficiency currently exist and focusing on GE rice could undermine such established initiatives.*

** Millions of dollars have been poured into research for GE rice, and much more will be needed before it stands a chance of becoming widely available. It would be much more cost-effective to allocate those funds to existing strategies (See Appendix C: Existing strategies to fight Vitamin A Deficiency), i.e. promoting locally appropriate and ecologically sustainable agriculture and diet diversification programmes.*

** GE Rice, like other genetically modified organisms (GMOs) released into the environment, is a form of living pollution and its environmental impact is not only unpredictable and uncontrollable but also irreversible.*

APPENDIX A: GENETICALLY ENGINEERED VITAMIN A RICE

Plans to bring Vitamin A rice from the laboratory to the field and subsequently to the victims of VAD are still in their infancy.
GE rice inventors say the rice would be available for local planting and consumption in 2004 at the earliest and general breeding experience suggests that it would take at least four to five years to produce marketable seed varieties.

In 1991, research groups in Zurich (a team led by Dr. Ingo Potrykus of the Swiss Federal Institute of Technology) and Freiburg, Germany (Beier et. al) developed the idea of introducing Beta-carotene into the grain (endosperm) of rice, in order to try to convert this staple crop into a source of vitamin A in VAD affected areas.[36] In January 2000 the group of scientists published its results in *Science*[37].
Researchers genetically engineered a laboratory variety of japonica rice (Taipei 309, adapted to temperate weather in Europe rather than to tropical areas) and introduced in it a metabolic pathway so that part of a precursor of a hormone (geranyl geranyl diphosphate) present in rice is converted into Beta-carotene.[38]
The research team also inserted three foreign genes in the rice: two from daffodils (*Narcissus pseudonarcissus*) and one from the bacterium *Erwinia uredovor*.

In January 2000 the scientists reported that they had achieved their goal of creating the first samples of Beta-carotene-rich lines of rice.[39]
The major donor of the GE rice project over the past six years was the Rockefeller Foundation, which supported the GE rice research as part of its 100 million-Dollar rice biotechnology programme. Additional funds also came from the European Union's Biotechnology programme FAIR[40], the Swiss federal office for Education and Science and the Swiss Federal Institute of Technology.

According to Prof. Potrykus, his team intends to co-operate with International Agricultural Research Centres (IARCs) -- including the Philippine-based International Rice Research Institute (IRRI), the India-based ICRISAT, the China based CNRRI and the Colombia-based CIAT -- where further cross-breeding and field tests will be carried out.
IRRI, together with the Philippine Rice Research Institute (PhilRice), is set to transfer the trait to other varieties as soon as its application receives the approval of the National Committee on Biosafety of the Philippines.

The genetically engineered trait would have to be transferred to predominant *indica* rice varieties used in Asia. Gary Toennissen of the Rockefeller Foundation announced that the transgenic rice would be combined with new high-yield varieties developed by IRRI in the Philippines.[41]
IRRI plans to insert the trait into high yield varieties -- such as IR64 -- which are widely grown in friendly, irrigated environments.[42]

APPENDIX B: VITAMIN A DEFICIENCY

Vitamin A deficiency is one of several micronutrient deficiencies that have plagued humankind over centuries and which still pose a massive public health problem. Other micronutrient problems include deficiencies in Iron (anemia), Zinc, Iodine (goiter), Vitamin D, Riboflavin, Selenium, and Calcium.
Vitamin A deficiency is a disease of the poor, of those who have only access to little or very little food. It is part of the "hidden hunger" which, according to some estimates, affects as many as two billion citizens around the world.

> *"Because people for the most part are not aware that their diets are lacking in this trace nutrients and hence do not associate these deficiencies with listlessness, poor eyesight, impaired cognitive development and physical growth, and more severe bouts of illness (sometimes leading to death), this general problem of poor dietary quality has been dubbed "hidden hunger"*
> **Bouis H.E. 1995. Breeding for nutrition**[43]

The number of people affected by "hidden hunger" (those who may appear to get enough to eat but in fact lack adequate micronutrients and fats) is two and half times larger than the 800 million undernourished people world-wide[44].
While most forms of "hidden hunger" have been overcome in industrialised countries over the past century, they still remain a major source of health problems in developing countries. Mineral and vitamin deficiencies affect some 40% of the world's population and have their most devastating effects on children and pregnant women.

Vitamin A Deficiency can lead to total blindness (or xerophthalmia) in children and to night-blindness: at least 350 000 pre-school children become partially or totally blind every year due to Vitamin A Deficiency.
14 million pre-school children already have some eye damage due Vitamin A Deficiency. About 60% of these children die within a few months of going blind.
Among the children under 5 years of age affected by Vitamin A Deficiency, some 3 million have signs of total blindness. Nevertheless, most of the children affected by VAD — between 140 and 250 million — present only subclinical manifestations, yet live with a greater risk of mortality and the risk of being susceptible to severe infections.[45]

Vitamin A deficiency is also common in pregnant women. Recent studies have shown that pregnant women who are vitamin A deficient are at a greater risk of dying during or shortly after delivery and that weekly, low-dose supplements given to women during pregnancy can reduce maternal mortality by 50%.[46]
VAD also weakens the immune system thus considerably increasing child but also adult mortality from infectious diseases. According to the World Health Organisation, about 250 million children are sub-clinically deficient (have low levels of Vitamin A in blood but no eye symptoms). [47]
VAD contributes to the estimated 1.1 million childhood deaths from measles every year.[48] It has also been associated with increased susceptibility to Malaria[49] and HIV/AIDS transmission of mothers to babies.[50]

While Vitamin A was only identified in 1913, Vitamin A deficiency has been fought long before and has practically eradicated in Europe during the early decades of the 20th century.
However, it was only in the mid 80s that Vitamin A's crucial role for the immune system and the association of VAD with child mortality were identified and acknowledged. In the '90s the international community pledged in a series of conferences to eradicate VAD by the year 2000.[51] [52]
Massive programmes of fortification and supplementation with Vitamin A have been started over the past years. According to the WHO, vitamin A supplement coverage among children or widespread access to fortified foods was greater than 50% in about 30 countries affected by VAD in 1997.

In 1998, 40% of the 96 countries where VAD is a public health problem included Vitamin A supplements in their national immunisation days. However, measures to improve dietary intake by increasing production of vitamin A-rich foods or facilitating access to them are still limited. Nearly 30% of the countries where VAD is likely to be a public health problem have not yet estimated the magnitude of the deficiency and therefore have not yet developed strategies for action.[53]

APPENDIX C: EXISTING STRATEGIES TO FIGHT VITAMIN A DEFICIENCY

The fight against VAD has actually received substantial funding from international agencies, foundations, donors, governments and businesses over recent years.
However, the goal of eradicating VAD is still far from being reached. Out of the 96 countries in which VAD was identified as a public health problem in the early 1990s only 30 have managed to eradicate VAD.

The 1992 "World Declaration and the Plan of Action on Nutrition"[54], unanimously adopted by 159 countries at the International Conference on Nutrition jointly organised by FAO and WHO, emphasised inter alia that strategies to combat micronutrient malnutrition should: *"Ensure that sustainable food-based strategies are given first priority particularly for populations deficient in vitamin A and iron, favouring locally available foods and taking into account local food habits".* The declaration also added that *"Supplementation should be progressively phased out as soon as micronutrient-rich food-based strategies enable adequate consumption of micronutrients. "*

There are three strategies to ensure sufficient Vitamin A levels in vulnerable populations: Supplementation, food fortification and dietary diversification. All of them play an important role in present efforts.

1- Supplementation: Periodically handing out oral doses of synthetic Vitamin A to children and mothers can be a cost-effective emergency intervention, especially when coupled with other immunisation programmes. It is however not a long-term solution, especially for less visible sub-clinical levels of VAD.

2- Food fortification: Adding Vitamin A to processed food such as butter, margarine and sugar is also effective in populations with regular access to processed food. This measure has been implemented successfully in most industrialised countries over the past 70 years. It requires co-operation with food processors and appropriate strategies to reach the populations most in need.

3- Dietary education and diversification: It is broadly recognised as the best long-term solution. It requires diverse and locally adapted efforts as well as co-operation with all stakeholders involved. A variety of programmes promoting access to and use of freely accessible or cheap sources of vitamin A as well as other micronutrients have proved to be highly efficient.

In order to eliminate VAD and related micronutrient deficiencies, access to Vitamin A-rich food is the only sustainable long-term solution. For new-borns, breastmilk is usually the only source of Vitamin A. Accordingly, promoting breastfeeding and ensuring sufficiently high Vitamin A levels in breastfeeding mothers are an essential part of any VAD reduction strategy.

Animal products are rich in Vitamin A that can be directly absorbed by the human body. Many fruits, vegetables and other green plants, such as carrots or drumstick leaves, contain sufficient amounts of Beta-Carotene which is then converted by the human body into Vitamin A. Two tablespoons of carrots contain enough Beta Carotene to cover our daily needs.

A diet rich in Vitamin A and other micronutrients is a luxury for millions of poor, not because such foods are not available in their countries, but because they cannot afford them and/or have no access to them. This is a problem that GE rice would not solve.

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In the short run, however, donors and governments may have to assume a major financial burden for project preparation, start-up costs, and recurrent costs in the early years. The economic and social payoffs from micronutrient programs reach as high as 84 times the program costs. Few other development programs offer such high social and economic payoffs. http://www.worldbank.org/html/extdr/hnp/hddflash/issues/00073.html

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52 "1990 World Summit for Children, the 1992 International Conference on Nutrition, and the 1996 World Food Summit. Over 159 countries and the European Union pledged to virtually eliminate iodine and vitamin A deficiencies by the year 2000 and reduce by one third the 1990 levels of iron deficiency anemia in pregnant women. Participants in these forums reiterated the need for societies to surmount the costs of malnutrition, especially when both scientific knowledge and realizable programs were available (2, 89). Of the 108 World Health Organization (WHO) member states represented at the conferences, at least 53 with identified micronutrient problems have national nutrition plans of action that specifically address public health

micronutrient issues (WHO global data bank: Implementation of the World Declaration and Plan of Action for Nutrition, 1997). In planning new actions, these states have followed advice from internationally generated documents (23, 79, 100, 104) and suggestions made by international consultants. Some countries reexamined their existing national plans and updated their policies in view of long-term goals. Global investment has provided support for assessment and interventions in countries with populations presumed deficient (2)." Source: Underwood B.A., and S. Smitasiri, 1999, Annual Review of Nutrition; Vol. 19; p. 303 Micronutrient malnutrition: Policies and programs for control and their implications.

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