

Golden Rice



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Preface

When we started to look for an adequate topic, we went through a list of potential examples for genetic engineering. While we were reading through the list, we tripped over "Golden Rice" and wondered what that was - because we ourselves are eating (white) rice every day - which is why we wanted to know more about that. After we have made some researches about that special kind of rice, we found it the most interesting topic - so we took it.

While we were investigating, we also found out, that it's a recent project that's still going on and makes a very good impression in its intention. Hence, it is about combating world hunger and helping poor people to get a healthy nutrition. Besides, it also sounded very realistic and helpful even for the farmers, because it's inexpensive and free of charges, giving the farmers the opportunity to grow it on their own.

What we particularly wanted to know is:

- Did/does it really help?
- What progresses were made till now?
- Are there any disadvantages or side-effects (it was quite suspicious to us that there only seem to be good aspects about the project)?
- What are the next steps?
- Is this really the best solution?
- Are there any (more natural) alternatives?

The picture at the front shows the different colour of Golden Rice in comparison to usual white rice. This typical yellow/orange colour comes from the beta-carotene, which normal rice does not have.

Introduction

Golden Rice is a genetic modified type of rice, to combat Vitamin A Deficiency in mostly low-developed countries, where rice is a main food source. It is modified in the way, that the edible part of the rice plant will contain beta-carotene (pro-vitamin A), which turns into vitamin a in the stomach.

The goal is to help people who suffer from Vitamin A Deficiency (VAD), which is responsible to blindness, affection of the immune system, and many deaths. Especially children and pregnant women are at highest risk. Because most countries, highly affected by VAD, rely on rice as a staple food, it's quite wise to enrich rice with beta-carotene, when the plant itself is producing this pro-vitamin A anyway. It's a simple and less expensive alternative –or rather addition- to vitamin supplements or to an increase in the production of green vegetables or animal products.

Golden Rice was invented by Ingo Potrykus from the ETH in Zurich, together with Peter Beyer from the university in Freiburg. The project started in 1992 and the first results were published in 2000.

They say it's a humanitarian project, which is why they –and other scientists- refuse to have any financial interest. Although Golden Rice has many patents on it, they also refuse the license fee, so that everyone is allowed to evolve and further develop Golden Rice. They offer the seeds to the poorest farmers, so that they can grow it on their own.

Alternatives

To avoid nutritious deficiencies, people should have a varied diet, rich in vegetables, fruits and animal products, or for those who cannot afford a varied diet the best way is to have nutrient dense staple crops.

Although animal sources are expensive, inexpensive plant food source should be widely available. For instance, it only takes one tablespoon of coriander leaves, two tablespoons of yellow sweet potatoes or two-third of a mango per day, to reach the vitamin A requirement of a child. Also, many Indian vegetables contain higher amounts of beta-carotene than Golden Rice does.

Applied Technique

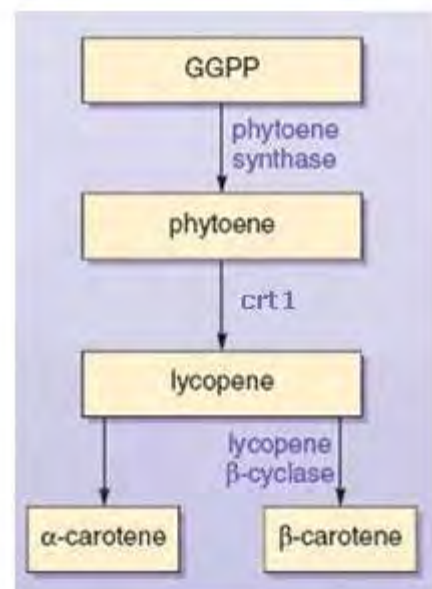
Rice plants produce beta-carotene in green tissues but not in the endosperm (edible part of the seed), because it does not have to perform photosynthesis. But the endosperm contains many valuable nutrients instead, e.g. vitamin B and nutritious fats but unfortunately no pro-vitamin A. Only in the outer coat of grains are beta-carotenes, but these nutrients are lost in the process of milling and polishing. Unprocessed rice would have those important nutrients, but the fatty component is affected by oxidative processes that make the grain turn rancid in a short period of time. In the guts, pro-vitamin A turns into retinol (vitamin A).

The goal now, is to make the endosperm produce the beta-carotene as well.

This can be done by inserting two beta-carotene biosynthesis genes into the nuclear genome and place them under the control of an endosperm specific promoter, so that they are only expressed in the endosperm.

GGPP (geranylgeranyl-diphosphate) is the starting molecule of the carotene-biosynthesis pathway. First it needs to fuse with another GGPP, which can happen by the process of phytoene synthase (by adding enzymes of the *Narcissus pseudonarcissus* (daffodil flower) resulting in a phytoene. This leads to further reactions, catalysed by the bacterial desaturase (crt1) from a bacteria called *Erwinia uredovora*. The resulting product (lycopene) only needs to be transferred into beta-carotene by the process of lycopene cyclase.

Thus, these two genes are responsible for the endosperm having beta-carotene as well.



Progress Made

First, Syngenta donated money for the research of this humanitarian project and its use in developing countries, free of charge. After the investigation went ahead with successful field tests in Louisiana (in 2004), the improved version of Golden Rice was soon invented in the year of 2005. This “Golden Rice 2” has a 23 times higher amount of carotenoids than the former type of rice contained, so that only 75g have to be eaten to reach the recommended level of vitamin A per day.

The only difference in the process of creating Golden Rice 2 is that the enzyme catalyzing the phytoene synthase was not taken by the daffodil flower anymore, but simply by maize, which scientists found more effective.



(Stages of Golden Rice)

Future Steps

The next steps referring to the project of Golden Rice will surely be to educate farmers and consumers after having conducted further tests about whether Golden Rice 2 is safe for human consumption. With that, IRRI (International Rice Research Institute) and PhilRice plan to launch Golden Rice 2 for the market in 2012, in order to reduce VAD-related diseases and to provide the recommended daily amount of vitamin A in form of beta-carotene, for those who need it.

How “Good” Actually Is Golden Rice?

Pro

- High percentage of VAD caused diseases and deaths can be prevented by Golden Rice.
- It is said to be a “humanitarian project” - inventors refuse financial interest.
- It was developed by an independent research group → Golden rice can be increased by the farmers themselves
- Beta-carotene already was in the rice plant anyway.
- Golden Rice was never to be thought to satisfy human need of vitamin A on its own, but rather as an inexpensive supplement to poor people's diet.

Contra

- It is criticized for not advancing faster in establishing its capacity to reduce VAD.
- Golden Rice (2) is not approved for human consumption yet.
- Golden Rice 1 was criticized for not having sufficient beta-carotene (several kilos had to be eaten per day in order to take up enough vitamin A per day).
- There are doubts about the speed at which the content of vitamin A degrades once the plant is harvest and how much of it will remain after cooking.
- Varied diet containing food rich in vitamin A need fat, which most people under these conditions do not have much in their diet.
- Problems often lies in the lack of money and land (and other circumstances like political instability (war) or missing hygiene (absorbing all vitamin A)), resulting in incapability of having a broad availability of diverse sources of food (loss of traditional nutrition and biodiversity → malnutrition). Some say that it is even the Green Revolution with all its (genetic modified) crops that makes people lose their land...But fact is, that VAD unfortunately is only the result of a much bigger problem, which can not be addressed by Golden Rice.

- Malnutrition may even increase by introducing people to more unbalanced diets, relying on only a few highly nutritional crops.
- Apparently there are traditional types of rice in Asia that contain much more beta-carotene than Golden Rice 1 does. It is just located in the rice shell. (Milled rice was introduced with the Green Revolution).

Summary

Golden Rice is a genetic modified kind of rice, where the edible part of the plant is enriched with beta-carotene, which turns into vitamin a in the stomach of humans and animals. It's thought to combat Vitamin A Deficiency in rather low developed countries, where rice is a major staple crop. Because people there mainly feed on rice and the rice plants already contain beta-carotene (unfortunately not in the endosperm = edible part) it is a clever and inexpensive way to increase the amount of beta-carotene (pro-vitamin A) in the diet of those people.

To achieve that the endosperm also contains beta-carotene, two different genes are placed into the nuclear genome.

There are discussions going on about Golden Rice with many aspects e.g. some argue that Golden Rice does not contain enough beta-carotene, so that several kilos of rice have to be eaten in order to reach the needed amount of vitamin A per day. But there are new strains of Golden Rice, namely Golden Rice 2, with a much higher amount of beta-carotene. Golden Rice was never thought to be the only mean to cover all necessary vitamin A, but rather as an inexpensive complement to other alternatives.

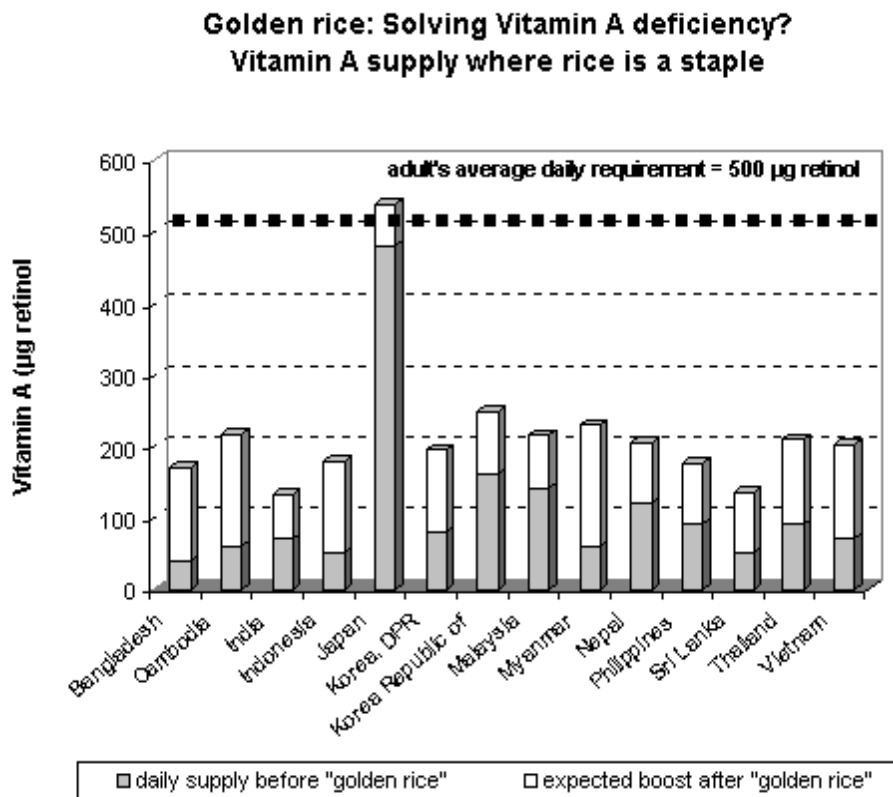
Another argument is that malnutrition is a small part of the overall problem because it's more about landlessness and poverty, and to take up (pro)vitamin A, there need to be enough fat, which poor people do not have in their diet either. But in low developed countries rice is already the main source of fat, which actually is just fine with Golden Rice. Another critical point is that Golden Rice is not approved for human consumption yet.

But all in all it is still in progress and researchers are still working on further development and tests.

Conclusions

We would say that the idea is not bad, because the rice plant itself already contains beta-carotene. But it's still better to consider Golden Rice as an additional complement, when people are not able to grow much of a variety of other fruits and vegetables that have a high nutritional level.

We think, it can especially help the poorest people who have no other option than to rely on a few -but highly nutritional- food sources and for most Asian countries, rice already is a major food source. Because VAD is not the "real" problem, best would be to continue and improve the project of Golden Rice (2), but also try to focus more on the bigger causes like poverty, landlessness etc. and grow other vegetables - if possible.



(This graph shows, how much the vitamin A supply would hypothetically increase after Golden Rice was introduced)

We only ask ourselves, why they invest so much money in researches and investigations, while it would be much easier just to grow more e.g. coriander (only one spoon of those leaves are enough to satisfy the need of vitamin A per day...).

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