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An Overview of Nutritional and Economic Importance of Golden Rice: Past and Future Prospects

Pallavi Kumari[1], Sajal Saha[2*], Sentisuba[2], Deepa Bhadana[1] and Nishtha[3]

[1]*Chaudhary Charan Singh University, Meerut - 250001, India*
[2]*Nagaland Central University, Medziphema - 797106, India*
[3]*Forest research institute, Dehradun, India*

**Corresponding author*

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A B S T R A C T

The Golden Rice Project was established to combat vitamin A deficiency worldwide. Rice, as we all know, is a major grain crop grown all over the world. Beta-carotene and vitamin A are not found in white rice. Rice-eating countries have a higher rate of vitamin A deficiency. Vitamin A deficiency has been linked to death in low-income countries in the past. Vitamin A deficiency can contribute to disorders such as night blindness, which can progress to blindness, eye and skin dryness, and maternal mortality. Vitamin A insufficiency affects around 250 million children, according to the World Health Organization. It includes beta-carotene, which is responsible for the golden yellow colour of the grain. Two daffodil genes and one bacterium gene were employed.

Introduction

Rice (*Oryza sativa*) belongs to the Poaceae family of monocots. Rice is the sole source of income in East and Southeast Asia. Rice is grown in Asia for 90% of the world's supply, primarily in China, India, Indonesia, and Bangladesh. Rice is also farmed in smaller quantities in Japan, Pakistan, and many Southeast Asian countries, as well as in areas of Europe, North and South America, and Australia. In 2010, Thailand, Vietnam, and India were reported to account for over 70% of global exports. Ingo Potrykus and Peter Beyer of Germany developed golden rice in the late 1990s to combat vitamin A deficiency, which causes blindness in infants. Rice was genetically engineered to produce golden rice. Rice's genome was inserted with a multi-gene biochemical system that produces beta-carotene. The Golden Rice initiative was funded by the US Rockefeller Foundation. Beta-carotene was discovered in rice after it was modified in the lab, but no country had commercially farmed it as of 2013. The golden colour, which is induced by beta-carotene, gave it its name. Three genes from daffodils (psy, Icy) and one from bacteria were introduced for the first time in rice embryos (crt1).

Rather than commercialising Golden Rice, Ingo Potrykus and Peter Beyer laboured to make it for the benefit of society. The two scientists formed a "Golden Rice Humanitarian Board" to monitor the technology's progress. In December 2019, the Philippines' government issued a green flag to golden rice, indicating that it is safe to consume.

The Philippines' Bureau of Plant Industry issued a safety clearance for commercial Golden Rice cultivation on July 21, 2021. Vitamin A deficiency affects one out of every five underprivileged children in the Philippines. Rice can be commercially planted, according to Dr. John C. De Leon, executive director of the DA-Philippine Rice Research Institute, however varietal registration by the National Seed Industry Council is still required. From the countries that have issued safety clearances, such as Australia, New Zealand, Canada, and the United States of America, the Philippines is the first to permit commercial production of Golden Rice.

Economic Importance

More individuals can be fed and nourished, resulting in people who will contribute to the economy through the labour force. The market for genetically engineered crops will be expanded. The development of new markets with high return potential will be advantageous to the economy and its growth. Many nations do not allow genetically modified crops, and if Golden Rice is accepted and commercially farmed, which only the Philippines will do for the time being, there will be an increase in GMO crop production, resulting in thousands of job opportunities. If new work possibilities emerge, the unemployment rate will almost certainly decline. All of this would be conceivable if Golden Rice were to be released to the market, but in the current situation, the opposite is true. Predictions can be made about Golden Rice; it will solely be determined by supply and demand, with price playing a significant impact. According to the International Rice Research Institute, the price of golden rice should not outperform the price of white rice (when available in the market). Different scenarios will be created based on the predictions made, each of which will have an impact on the demand and supply chain. Whatever the case, the expense of producing Golden Rice will make it significantly more expensive than white rice.

Golden Rice 2

In 2005, Syngenta created Golden Rice 2 by combining the phytoene synthase gene from maize with the crt1 gene from the original Golden Rice. Golden Rice 2 produces up to 23 times more carotenoid.

Chemical Composition

Future Prospect

If commercially accepted, genetically modified crops have a lot of potential. Farmers will have peace of mind if disease and pest resistant rice cultivars are developed. Drought, cold, and heat are all factors that impede rice development, yet genetically modified rice can overcome them. Furthermore, Golden Rice would meet the nutritional requirements of the underprivileged. All of this is made feasible by the crop's commercialization.

Methods of Production

Golden rice is created by combining two genes: psy (Phytoene synthase) from the daffodil and crt1 (Carotene desaturase) from the soil bacterium. The psy and crt1 genes were first introduced into the rice genome and placed under the control of an endosperm-specific promoter, allowing them to express only in endosperm. Co-transformations were carried out using two vectors, one (pZPsC) carrying psy and crt1, and the other (pZCycH) carrying the beta-carotene biosynthetic pathway. Lycopene beta – cyclase, like phytoene synthase, possesses a functional transit peptide that permits plastid import. In rice endosperm, a combination of both plasmids should be able to direct beta-carotene synthesis.

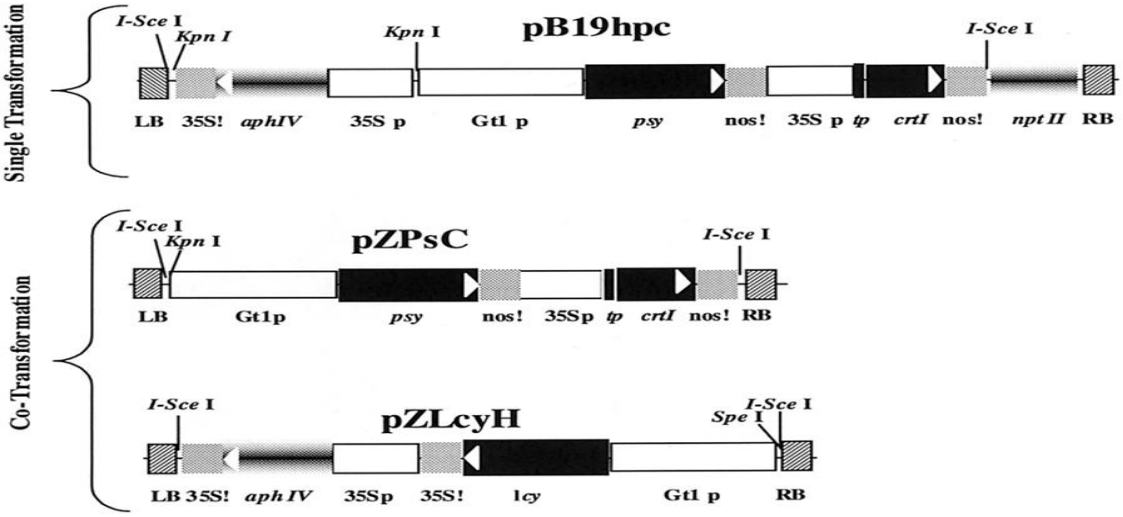
Table.1 Proximate, Fiber and Mineral Composition of Grain, Straw and Bran Samples derived from GR2E

Component	Mean	Range
Grain Samples		
ash(%DB)	5.89	4.95-7.17
crude fat(%DB)	1.42	0.84-2.16
crude protein (%DB)	8.1	6.07-11.2
ADF(%DB)	18.5	15.7-21.7
NDF(%DB)	22.1	17.5-35.5
Crude fiber(%DB)	12.0	10.1-14.6
TDF(%DB)	17.0	12.8-20.3
Amylose (%DB)	12.9	7.31-18.6
Starch(%DB)	59.5	32.8-71.5
Ca(mg/100g DB)	22.5	14.2-35.0
Fe(mg/100g DB)	3.96	2.37-10.6
Mg(mg/100g DB)	131	87.5-185
Mn(mg/100g DB)	6.61	4.33-8.39
P(mg/100g DB)	327	211-461
K(mg/100g DB)	346	236-597
Na(mg/100g DB)	1.5	0.56-3.81
Zn(mg/100g DB)	2.31	1.63-3.21
Straw Samples		
Ash(%DB)	25.7	21.1-30.4
Crude fat (%DB)	2.58	1.31-4.8
Crude protein (%DB)	6.13	3.16-11.3
ADF (%DB)	52.6	46.1-58.0
NDF(%DB)	62.5	56.3-68.9
Crude fiber(%DB)	30.1	26.9-35.8
Ca (g/kg DB)	3.77	1.75-7.06
P (g/kg DB)	1.52	0.82-3.61
Bran Samples		
Ash(%DB)	10.3	10.0-10.6
Crude fat(%DB)	24.1	23.8-24.4
Crude protein (%DB)	15.1	14.7-15.6
ADF(%DB)	16.0	11.6-20.4
NDF(%DB)	23.7	23.7-23.8
Crude fiber (%DB)	8.97	8.31-9.63
Ca (g/kg DB)	0.62	0.46-0.77
P(g/kg DB)	25.9	25.8-26.0

[Source: Journal of Agricultural and Food Chemistry]

Fig.1

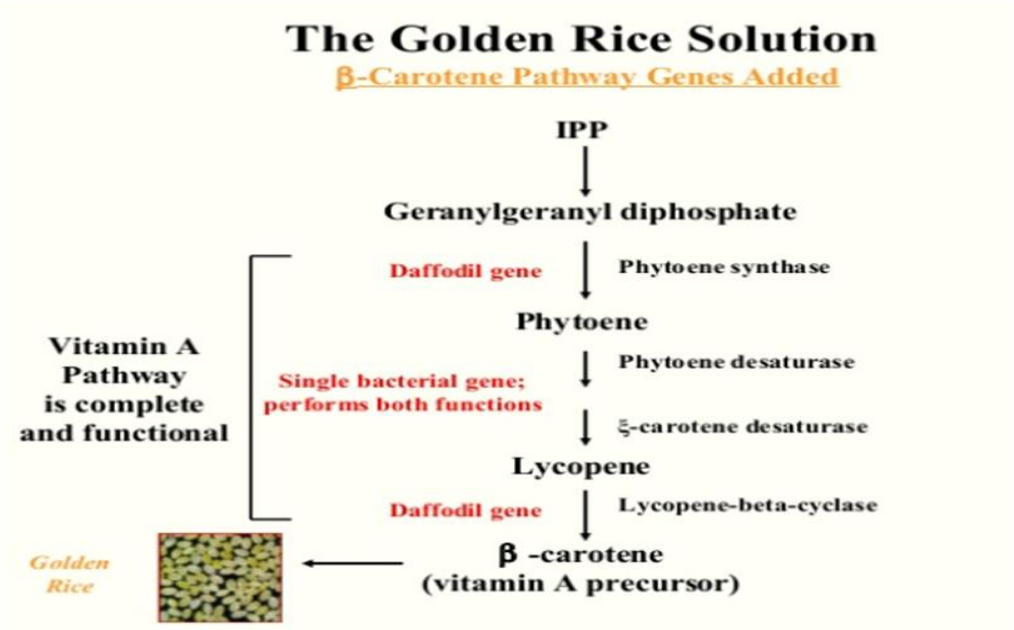
Fig: Single and co-transformation of psy and crt1 gene



Source: JN The Journal of Nutrition

Fig.2

Fig: Biochemical Pathway of Golden Rice



Source: American Council On Science and Health

Despite the prevalence of genetically modified rice, vitamin A deficiency remains a public health concern. Golden Rice will give them with nutrients (vitamin A). People's health will be improved via bio-fortification of staple foods. Golden Rice's quick expansion will be aided by commercialization. The number of deaths caused by vitamin A deficiency will decline. Golden Rice may now be grown commercially in the Philippines. According to some scientists, Golden rice contains a negligible quantity of vitamin A, for which it was genetically modified. Because the setup for growing Golden rice might be costly, replacements should be sought. Because this project was established for the benefit of society, if it is commercialized, it will aid in the reduction of childhood blindness and the mortality rate among pregnant women.

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