Table of Contents

Total Word Count: 1593 (Excluding References and Figure legends)

Use of GM plant in Human Health

Introduction

Genetically modified plants have foreign DNA transferred into their cells to give them different characteristics. These cells containing new DNA in them are allowed to grow in tissue culture to develop into a plant. The seeds of this plant have inherited new DNA with new characteristics. Various methods have been used for the alternation of genetic characteristics of the plant cell. These methods may be biological, physical, or chemical. The biological methods include plant virus vectors and Agrobacterium-mediated type gene transfer. The physical methods include microinjection, electroporation, microprojectile, and liposome fusion. The chemical methods include polyethene mediated glycol and diethylamino ethyl dextran mediated. Many genetically modified plants have been produced for various purposes. These aims include improving nutritional quality, biotic stress tolerance, insecticide resistance, enhanced self-life, abiotic stress tolerance, herbicide resistance, human and animal health applications (Singh, 2021).

Example of application of GM plant in human health

There are a lot of practical applications for genetically modified plants found commercially and also some in practice for improving human health. Many nutritional enhanced foods have been produced from genetically modified plants for improving the nutrient intake of an individual to give rich ingredients intake. These have been used in preventing or controlling several diseases that could lead to human death if left uncontrolled. These diseases include diabetes, hypertension, cancer, vitamins deficiencies, and cardiovascular disease. The example which has discussed in this essay is the use of a genetically modified rice plant named golden rice for improving vitamin A deficiency in humans that could lead to childhood blindness if left uncontrolled (Dubock, 2019).

Golden Rice (GM Plant)

It is a golden coloured rice variety that has been produced by genetic engineering of rice plants by insertion of beta-carotene into it. This beta-carotene when utilized by the human body got converted into vitamin A because it is a precursor of it. Figure 1.1 have golden coloured rice in the left bowl while it contains simple rice in the right side bowl (Charles, 2013).

Figure 1.1: Golden coloured (GM Plant) and simple rice

(Charles, 2013)

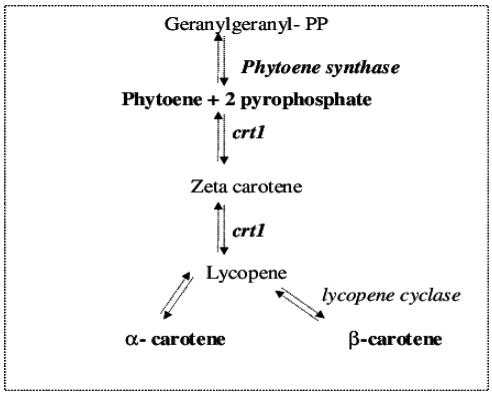
Golden Rice for treating malnutrition

Malnutrition is a significant issue in the world. When humans particularly children lack sufficient nutrition which includes the essential minerals and vitamins, this led to the arousal of more chances of health problems and numerous diseases in them. A million humans in the world depend on rice as their primary diet staple but rice does not have vitamin A naturally. Those children who have vitamin A deficiency are at greater risk of evolving blindness in them and this deficiency also influences measles and diarrhoea severity. The World Health Organization (WHO) estimated in 2012 that the preschool children who have been affected by lack of vitamin A in them are around 250 million globally. Vitamin A deficiency (VAD) affects 250, 000-50,000 children every year to get blind and half of them die each year due to this health issue. This deficiency is mostly seen in Africa and Asia where people are mostly poor and eat rice mainly. For combating this debilitating common health issue, beta-carotene has been added to rice strain by the process of plant genetic engineering. Beta-carotene has been used for inserting it into rice plants because it is a precursor of vitamin A as it is got converted into vitamin A during the human digestion process. This results in the production of the GM rice crop which is known as golden rice (GMO answers, 2022).

How GM rice plant has been produced?

Two genes have been used in the rice genome for making golden rice. The first gene Psy (Phytoene synthase) which have been derived from *Narcissus pseudonarcissus* (Daffodils). This gene is involved in the carotenoids' biosynthesis. This gene is a transferase enzyme as it catalyzes geranylgeranyl pyrophosphate conversion to phytoene. The second gene which has been used in making GM rice plant is crt11 (Lycopene cyclase) which have been taken from *Erwinia uredovora*, a soil bacterium. This gene act as a catalyst for beta-carotene (carotenoids) biosynthesis and produces enzymes in plant endosperm. Lycopene is the product of this engineered pathway but if the accumulation of lycopene occurs in genetically modified (GM) rice plants, then then it would give the red colour of rice. Figure 1.2 below shows the biosynthetic pathway for golden rice with lycopene as the end product (Murthy, 2005).

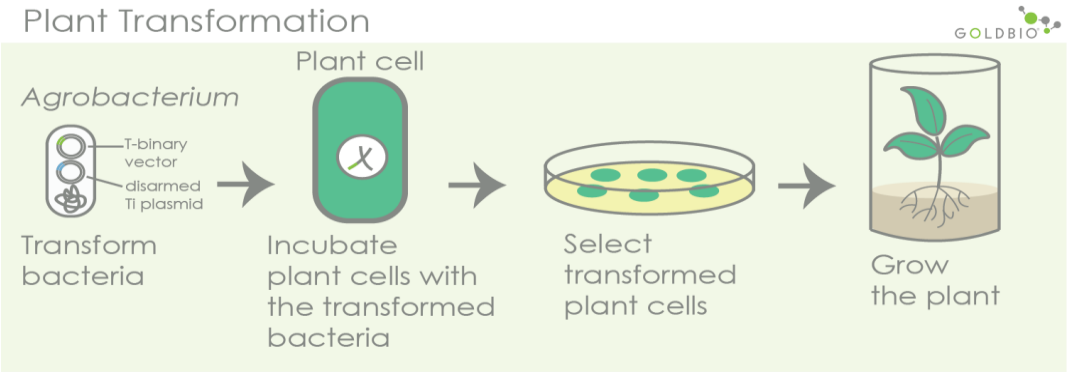
Figure 1.2: Biosynthetic pathway of golden rice



(Murthy, 2005)

These two genes with promoters that are DNA segments used for activating these genes are inserted into small DNA loops called plasmids. This all process occurs into bacterium species called Agrobacterium tumefaciens. It is a biological method of agrobacterium mediated gene transfer that has been used in it for making genetically modified rice plant. Figure 1.3 below shows the general agrobacterium mediated gene transformation for any plant into a genetically modified (GM) plant. Figure 1.3: General Agrobacterium gene mediated transformation process of plant cells.

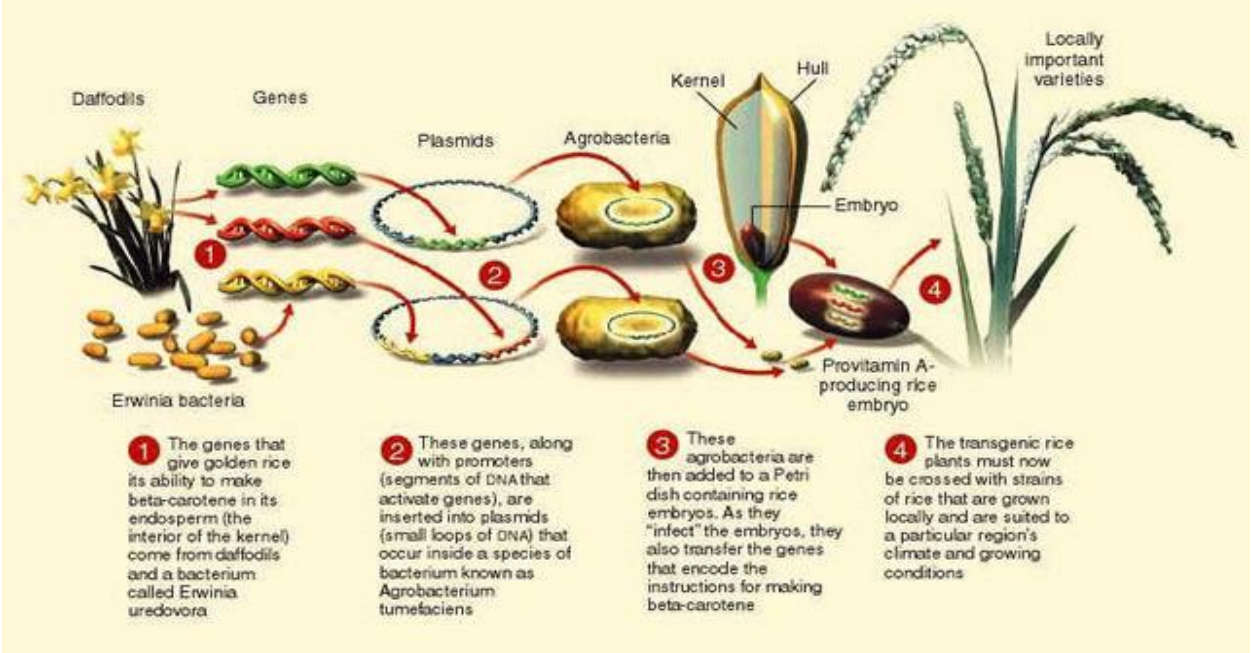
Figure 1.3: General Agrobacterium gene mediated process of GM Plant formation



(Kroemer, 2022)

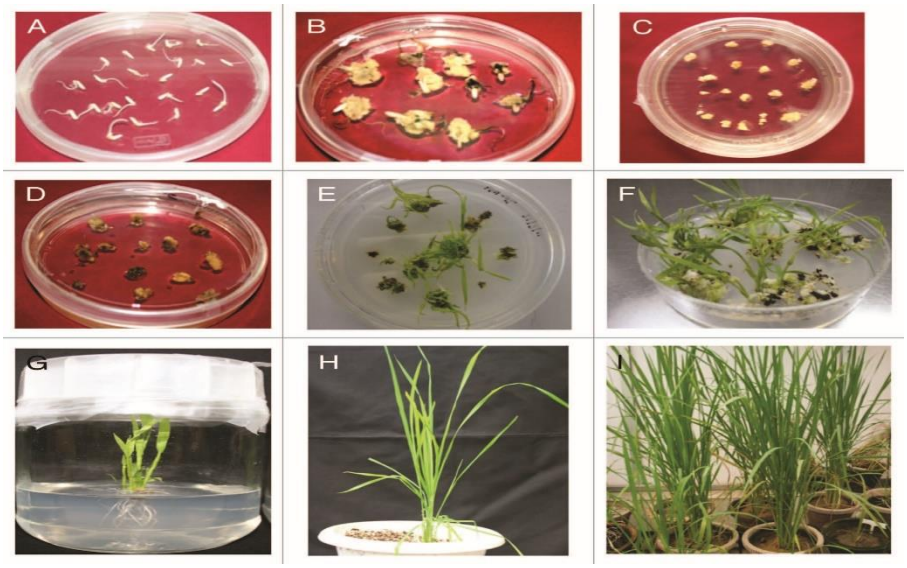
These agrobacteria having foreign DNA incorporated plasmids are then further added to a petri dish that contains rice plant embryos. This agrobacterium can affect the plant embryos by entering through the plant wound or cuts that is existing in its stem or root. This bacterium transferred its DNA with genes that encode beta-carotene making instructions into the rice plant during this process of agrobacterium mediate gene transfer method. Now, this rice crop is a transgenic plant, and it should be crossed with rice strains that grow locally under suitable growing and regional climate conditions. Figure 1.4 below is showing the step-by-step process of tissue cultures of rice plants being converted into genetically modified (GM) rice plants.

Figure 1.4: Step by Step process of Golden Rice formation



(Biotech Crops Backgrounders, 2022)

Figure 1.5: Agrobacterium-mediated gene transformation of original mature rice seed sample



(lifeasible, 2022)

Benefits of Golden Rice (GM Plant) in human health

There are many health benefits in humans found related to genetically modified (GM) rice plant-golden rice. These are found important for skin, vision, and treating malnutrition. The high intake of particular minerals and vitamins like carotenoids (beta-carotene) and vitamin A leads to reduce the risk of macular degeneration, coronary artery disease, and specific cancers. The carotenoid (beta-carotene) present in genetically modified (GM) rice plant is an antioxidant that is why proved to be very helpful in protecting the human body from such free radical reactions in the body which are destructive for human health and body. Malnutrition is a major problem worldwide. The malnutrition problem arises because human diets lack essential micro and macronutrients like lipids, minerals, carbohydrates, vitamins, and proteins. The major deficiencies that arise due to the lack of these essential nutrients are iodine, iron, vitamin E, and A. Therefore, using golden rice (GM Plant) as a food staple with rich diet ingredients globally proved to be very helpful in combating this serious human health issue of malnutrition worldwide (Buu, 2003).

Golden Rice research for Safety

Despite the benefits and increased nutritional value of the golden rice GM plant, the use of genetically modified plants as a food source is a controversial topic. The controversial concerns related to the use of GM plants include increased toxicity and allergenicity to Gm food could rise in some humans (Buu, 2003). Therefore, it is essential to test the genetically modified plant properly before practically implementing its commercial use worldwide. For this, multiple tests have been done among all human age levels including children too. The governmental organizations of various countries have tested the golden rice's safe use before officially approving it. This includes the Philippines. In Asian countries, rice is their staple food as they heavily rely on rice as their primary food daily intake. These countries are at higher risk of getting diseases like blindness due to deprivation of vitamin A deficiency. That is why the addition of golden rice (GM Plant) to their staple food could prove to be very beneficial for their health, especially for young children. The international institute of rice research continues testing golden rice-GMO crops globally for seeking its approval to grow golden rice strains by farmers for its commercial use worldwide (GMO answers, 2022).

Golden rice approval by FDA

The United States Food and Drug Administration (FDA) has officially approved this GM rice plant to be used worldwide in May of 2018. Its approval came shortly after its consumption approval in Canada and New Zealand. It was the first nutritional enhanced genetically modified (GM) rice plant for receiving regulatory approval for application in food (GMO answers, 2022). Now, it has been clearly outlined by FDA that golden rice genetically modified (GM) rice plant is safe for use in food for eating purposes (Greedy, 2018).

Conclusion

Golden rice is an excellent example of the use of GM (Genetically modified) plants in human health as it has been approved by FDA (Food and Drug Administration) to be used commercially worldwide. It has been approved for its real-life use in human health after conducting tests in the laboratory and on all ages of humans, especially children. It has been found important in treating malnutrition which is a serious worldwide issue. Golden rice contains beta-carotene in it which has been converted into vitamin A during the digestion process of humans. So, this GM plant (Golden rice) proved to be very helpful in treating vitamin A deficiency in humans, especially children which can lead to blindness or even death in preschool children if left untreated.

References

Biotech Crops Backgrounders. (2022, March 9). *Biotech Crops Backgrounders*. Retrieved from isaa.org: https://www.isaaa.org/kc/inforesources/biotechcrops/the_golden_rice_technology.htm

Buu, M. (2003). *Golden Rice: Genetically Modified to Reduce Vitamin A Deficiency, Benefit or Hazard?* eScholarship.

Charles, D. (2013, march 7). *npr*. Retrieved from The Salt, What's on your plate: https://www.npr.org/sections/thesalt/2013/03/07/173611461/in-a-grain-of-golden-rice-a-world-of-controversy-over-gmo-foods

Dubock, A. (2019). Vitamin A. In A. Dubock, *Golden rice: To combat vitamin A deficiency for public health* (pp. 1-21).

gmo answers. (2022, march 19). *gmo answers*. Retrieved from gmo answers: https://gmoanswers.com/golden-rice#:~:text=In%20the%20Philippines%2C%20a%20country,treating%20widespread%20vitamin%20A%20deficiency.

Greedy, D. (2018). Golden Rice is safe to eat, says FDA. *Nature Biotechnology, 36(7)*, 559.

Kroemer, T. (2022, march 19). *Gold Biotechnology.* Retrieved from goldbio.com: https://www.goldbio.com/articles/article/a-quick-overview-of-agrobacterium-for-plant-transformation

lifeasible. (2022, march 19). *lifeasible*. Retrieved from lifeasible.com: https://www.lifeasible.com/custom-solutions/plant/plant-transformation/agrobacterium-mediated-transformation-of-oryza-sativa/

Murthy, K. (2005). *Production Of Beta-Carotene from Cultured Dunaliella Sp. and Evaluation Of Biological Activities.* ResearchGate.

Singh, A. R. (2021). Transformation techniques and their role in crop improvements: a global scenario of GM crops. In A. R. Singh, *In Policy Issues in Genetically Modified Crops* (pp. pp. 515-542). Academic Press.