From Golden Rice to Golden Diets: How to turn its recent approval into practice

Hans De Steur a,*, Alexander J. Stein b, Matty Demont c

a Ghent University, Department of Agricultural Economics, Coupure Links 653, 9000, Ghent, Belgium
b European Commission, Directorate-General for Agriculture and Rural Development, 1049 Brussels, Belgium
c International Rice Research Institute, Los Baños, Laguna, Philippines

ARTICLE INFO

Keywords:
Biofortification
Consumer acceptance
Golden rice
Planetary health diets
The Philippines
Vitamin A deficiency

ABSTRACT

Following its approval in the Philippines in July 2021, provitamin A-rich “Golden Rice” is set to become the world’s first commercialized genetically modified crop with direct consumer benefits. Despite supplementation and fortification programs, the burden of micronutrient deficiencies remains high. For Golden Rice to be successful in reducing vitamin A deficiency, it needs to be taken up by food systems and integrated into consumer diets. Despite negative information often being associated with genetic engineering, evidence suggests that consumers react positively to Golden Rice. Thus, it offers policy makers and public health stakeholders a new, powerful option to address micronutrient malnutrition that they can integrate as a cost-effective component in broader nutrition strategies and tailor it to consumers’ heterogeneous socio-economic contexts and needs to promote “Golden Diets”. For this to happen, the right framing of the pathway from policy to consumption is crucial.

1. A history of controversy

July 2021 was yet another landmark for the strengthening of the agriculture-nutrition-health nexus, when the Philippines gave their green light for the cultivation of genetically modified (GM) Golden Rice, a rice variety biofortified with provitamin A (Science, 2021). Biofortification refers to the use of crop breeding or of agronomic practices to increase the mineral or vitamin content in crops to address micronutrient malnutrition and improve public health. Hundreds of conventionally biofortified crop varieties have already been released and shown impact and acceptance (Birol et al., 2015; CAST, 2020), but Golden Rice is set to become the worlds’ first commercialized GM biofortified crop.

After being declared safe for consumption in four countries (Australia, New Zealand, Canada and the United States) (Greedy, 2018), it is the Philippines that was the first to approve its cultivation, which is expected to happen in Bangladesh soon, too. Since Potrykus and Beyer developed its first version in 1999 (Qamar et al., 2020; Ye et al., 2000), Golden Rice has been facing sustained criticism that undoubtedly delayed the progress of this humanitarian project to help alleviate the health and economic burden of vitamin A deficiency (Wesseler and Zilberman, 2014). Carrying the legacy of the controversy over the widely adopted first-generation GM crops with farmer-oriented agronomic benefits (such as insect resistance or herbicide tolerance) may have intensified the struggle for approval of this second-generation GM crop with clear consumer benefits.

However, instead of looking (again) at the heated debate and polarization between proponents and opponents (Kettenburg et al., 2018), it is worthwhile to focus on how Golden Rice could be taken up by local communities and how its use could be better framed by policy makers, nutritionists and the scientific community.

2. The post-approval dialogue

When it comes to novel and controversial products, a routine dialogue takes place when positive new scientific evidence or policy decisions are published: pro-parties typically lend their support through positive messaging, quickly followed by anti-campaigning by opposing parties. In light of the upcoming commercialization of Golden Rice in the Philippines, the potential influence of information campaigns should not be ignored, not least at the level of consumers (and of farmers as consumers), who are the key beneficiaries of Golden Rice.

Information may be retained, whether it is validated or not. Translating consumer studies on Golden Rice and other GM biofortified crops

* Corresponding author.
E-mail address: Hans.DeSteur@ugent.be (H. De Steur).

https://doi.org/10.1016/j.gfs.2021.100596
Received 26 October 2021; Received in revised form 19 November 2021; Accepted 21 November 2021
Available online 29 November 2021
into practice (De Steur et al., 2015; Zheng et al., 2018), the interplay between positive and negative information on Golden Rice can be expected to affect consumer acceptance in some way or the other. Negative information associated with genetic engineering is certainly found to reduce peoples’ intentions to consume Golden Rice, but research has shown that it would not necessarily increase overall rejection rates as long as the nutritional benefits are highlighted (De Steur et al., 2017a). This is an important finding, as it suggests that, overall, negative information does not necessarily overshadow the effect of positive information. Currently the evidence overwhelmingly points to positive information associated with genetic engineering is certainly found to reduce peoples’ intentions to consume Golden Rice, but research has shown that it would not necessarily increase overall rejection rates as long as the nutritional benefits are highlighted (De Steur et al., 2017a). This is an important finding, as it suggests that, overall, negative information does not necessarily overshadow the effect of positive information. Currently the evidence overwhelmingly points to positive information associated with genetic engineering is certainly found to reduce peoples’ intentions to consume Golden Rice, but research has shown that it would not necessarily increase overall rejection rates as long as the nutritional benefits are highlighted (De Steur et al., 2017a).

4. Deploying Golden Rice and moving the debate forward

When commercialized, Golden Rice needs to take its place in the current food system, i.e. it needs to be taken up by value chains and integrated into food environments (where food acquisition and consumption takes place) and consumer diets. It is important to emphasize that this crop is not, or should not, be framed as a silver bullet—or a golden bullet, as it were—for ending micronutrient malnutrition. Rather, it has an important role in addressing a particular micronutrient deficiency that still imposes a considerable burden on public health and that requires innovative but cost-effective and culturally appropriate interventions that go beyond conventional vitamin A supplementation programs that typically target high priority population groups (children of 6–59 months old) (Hamer and Keusch, 2015). Implementing food-based solutions is particularly important as these are less vulnerable to disruptions caused by funding shortfalls or catastrophes, as shown most recently by the drop in vitamin A supplementation rates due to COVID-19 (HKI, 2020). Improving the micronutrient status of poor populations can also more generally contribute to stronger immune systems, which again is of particular importance to boost their resilience in case of (public health) crises (Heck et al., 2020).

Even though disseminating Golden Rice is expected to be a valuable and cost-effective complementary intervention to combat vitamin A deficiency in particular, to win the fight against malnutrition in general, it is time to move the framing forward and shift the debate. Instead of
discussing technological aspects of individual crops, such as Golden Rice, we need to come to an understanding of how to achieve “Golden Diets”, i.e. winning diets that are sustainable and wholesome.

One of the trail blazers in this respect is the EAT-Lancet Commission. It promotes a dietary shift towards “planetary health diets” that aim at striking a balance between human nutrition and planetary health (Willett et al., 2019). It acknowledges that despite nutrition programs, the burden of micronutrient deficiencies remains high and that for achieving planetary health diets, the adequacy of most micronutrients in low-income countries must increase—not least through greater consumption of fruits and vegetables, which are an essential source also of provitamin A.

However, the challenges for poor consumers are that (i) not only are their low incomes a barrier to more diversified and wholesome diets, also the relative prices of fruits and vegetables (higher compared to staple crops, such as rice) affect food consumption patterns (low intake of fruits and vegetables) and related health outcomes; and (ii) high prices and low incomes mean that wholesome diets (such as the EAT-Lancet diet) are well outside the reach of the average consumer in poor countries for the foreseeable future as they surpass their disposable daily incomes. Indeed, globally, about 3 billion people cannot afford the minimum cost of healthy diets recommended by national governments (Herforth et al., 2020). In addition to economic growth and nutrition-sensitive social protection, supply-side interventions that improve the affordability of nutritious foods are needed. This means that until widespread consumption of more diversified and wholesome diets is achieved through economic growth and nutrition-sensitive social protection, interventions that improve the affordability of nutritious foods will be crucial (Fan et al., 2021).

In this context, Golden Rice has a valuable role to play. It can be a provitamin A-rich component in broader interventions that rely on rice being a traditional and accepted staple to enable more nutrient-rich diets that better satisfy consumers’ physiological and nutritional needs than diets that are based on conventional rice. Such diets can still fit the respective socio-demographic, economic and cultural contexts and fulfill the hedonic motivations of the target groups (Custodio et al., 2021).

Once available on the market, Golden Rice will have to find its place within consumer diets, it will have to be paired to other ingredients in terms of its various sensory attributes (aroma, taste, color), and it will need to be incorporated into existing dishes or become the center piece of new ones. These dishes, in turn, will have to be integrated in eating occasions (breakfast, snack, lunch, dinner, and special occasions), which are determined by consumers’ culture, their socio-economic status and the food environments they are exposed to. All these components—the where, who, when, what, and why—are part of a system that needs to be optimized to achieve “Golden Diets” (Fig. 2).

The system provides multiple entry points for nutrition interventions to help consumers achieve such diets. For these interventions to have impact, they should be situation-specific and use multiple strategies that need to be tailored to consumers’ heterogeneous situations and needs (Custodio et al., 2021); e.g., using Golden Rice to diversify micronutrient strategies, or as a provitamin A-rich food item when promoting nutrient-rich diets to resource-poor target groups.

After a long series of delays in the regulatory process, the approval of Golden Rice in the Philippines marks an important breakthrough in the fight against vitamin A deficiency. Policy makers and public health stakeholders now have a new, powerful option to help target populations achieve planetary health diets. However, the success of Golden Rice and other nutritionally enhanced crops in the pipeline will crucially depend on two factors: (i) how these crops are integrated into national nutrition strategies; and (ii) how consumers manage to incorporate them into their daily lives in their efforts to achieve “Golden Diets.” Such diets can be another illustration on how to operationalize the EAT-Lancet planetary health diets (Béné et al., 2020), but it is up to policy makers to ensure that these crops are integrated as cost-effective components within a broader nutrition strategy, and to communicate to consumers that eating Golden Diets means winning.

Disclaimer

The information and views set out in this article are those of the authors and do not necessarily reflect the official position of the European Commission.
Author contributions

HDS: conceptualization, formal analysis, investigation, methodology, visualization, writing—original draft; MD, BJR: review & editing; AJS: formal analysis, investigation, methodology, visualization, writing—review & editing; MD: conceptualization, formal analysis, investigation, methodology, visualization, writing—review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Financing from the Bill and Melinda Gates Foundation, Seattle, WA, USA (Grant no. OPP1173178) and the CGIAR Research Program on Rice for the work of M.D. is gratefully acknowledged. These donors did not submit it for publication.

References

Bené, C., Fanjo, J., Haddad, I., et al., 2020. Five priorities to operationalize the EAT-Lancet Commission report. Nat. Food 1 (8), 457–459.
Birol, E., Meenakshi, J.V., Oparinde, A., Perez, S., Tomlins, K., 2015. Developing country consumers’ acceptance of biofortified foods: a synthesis. Food Sec. 7 (3), 555–568.
CAST, 2020. Food biofortification: Reaping the benefits of science to overcome hidden hunger. Issue Paper 69. Available at: https://www.cast-science.org/publication/food-biofortification-reaping-the-benefits-of-science-to-overcomehidden-hunger/ (accessed October 2020).
Custodio, M.C., Ynoion, J., Samaddar, A., et al., 2021. Unraveling heterogeneity of consumers’ food choice. Glob. Food. Sec. 28, 100497.
De Moura, F.F., Moursi, M., Donahue Angel, M., et al., 2016. Biofortified β-carotene rice improves vitamin A intake and reduces the prevalence of inadequacy among women and young children in a simulated analysis in Bangladesh, Indonesia, and the Philippines. Am. J. Clin. Nutr. 104 (3), 769–775.
De Steur, H., Blancquaert, D., Strobbe, S., et al., 2017b. Status and market potential of transgenic biofortified crops. Nat. Biotechnol. 35 (11), 25–29.
De Steur, H., Desmont, M., Gellynck, X., Stein, A.J., 2017a. The social and economic impact of biofortification through genetic modification. Curr. Opin. Biotechnol. 44, 161–168.
De Steur, H., Wesana, J., Blancquaert, D., Van Der Straeten, D., Gellynck, X., 2017b. Methods matter: a meta-regression on the determinants of willingness-to-pay studies on biofortified foods. Ann. N. Y. Acad. Sci. ANYAS 1290 (1), 34–46.
DOST-FNRI, 2020. Philippine Nutrition Facts and Figures: 2018 Expanded National Nutrition Survey (ENNS). Food and Nutrition Research Institute, Manila.
Fan, S., Headley, D., Rue, C., Thomas, T., 2021. Food systems for human and planetary health: economic perspectives. Annu. Rev. Resour. Econ. 13, 131–156.
Glover, D., Kim, S.K., Stone, G.D., 2020. Golden Rice and technology adoption theory: a study of seed choice dynamics among rice growers in the Philippines. Technol. Soc. 60, 101227.
Greedy, D., 2018. Golden Rice is safe to eat, says FDA. Nat. Biotechnol. 36 (7), 559.
Hamer, D.H., Keusch, G.T., 2015. Vitamin A deficiency: slow progress towards elimination. Lancet Glob. Health 3 (9), e502–e503.
Heck, S., Campop, H., Barker, I., et al., 2020. Resilient agri-food systems for nutrition amidst COVID-19: evidence and lessons from food-based approaches to overcome micronutrient deficiency and rebuild livelihoods after crises. Food Sec. 12 (4), 823–830.
Herforth, A., Bai, Y., Venkat, A., Mahrt, K., Ebel, A., Masters, W.A., 2020. Cost and Affordability of Healthy Diets across and within Countries. Background Paper for the State of Food Security and Nutrition in the World 2020. FAO Agricultural Development Economics Technical Study No. 9. FAO, Rome.
HIK, 2020. Building children’s immune systems in Kenya in the time of COVID-19. Available at: https://www.hki.org/our-stories/building-childrens-immune-systems-kenya-in-the-time-of-covid-19/.
Kettenburg, A.J., Hanspach, J., Abson, D.J., Fischer, J., 2018. From disagreements to dialogue: unpacking the Golden Rice debate. Sust. Sci. 13 (5), 1469–1482.
Oparinde, A., Birol, E., 2019. Value of nutrition: a synthesis of willingness to pay studies for biofortified foods. In: Ferranti, P., et al. (Eds.), Encyclopedia of Food Security and Sustainability. Elsevier, Amsterdam, pp. 197–205.
Potrykus, I., 2010. Lessons from the ‘humanitarian golden rice’ project. N. Biotechnol. 27 (5), 466–472.
Qamar, S., Tantray, A.Y., Bashir, S.S., Zaid, A., Wani, S.H., 2020. Golden Rice: genetic engineering, promises, present status and future prospects, in rice research for quality improvement. In: Genomics and Genetic Engineering. Springer, New York, pp. 581–604.
Science, 2021. Golden rice to sprout in the Philippines. Science 373, 472–473.
Stone, G.D., Glover, D., 2017. Disembedding grain: golden rice, the green revolution, and heirloom seeds in the Philippines. Agric. Hum. Val. 34 (1), 87–102.
Swamy, B.M., Marundan, S., Samia, M., Ordonio, R.L., 2021. Development and characterization of GR2E Golden rice introgression lines. Sci. Rep. 11 (1), 1–12.
Talma, E.F., Melse-Boonstra, A., Brouwer, I.D., 2017. Acceptance and adoption of biofortified crops in low- and middle-income countries: a systematic review. Nutr. Rev. 75 (10), 798–829.
Wesseler, J., Zilberman, D., 2014. The economic power of the Golden Rice opposition. Environ. Dev. Econ. 19 (6), 724–742.
Willet, W., Rockstrom, J., Loken, B., et al., 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet 393 (10170), 447–492.
Ye, X., Al-Babili, S., Kloti, A., Zhang, J., Lucca, P., Beyer, P., Potrykus, I., 2000. Engineering the provitamin A β-carotene biosynthetic pathway into carotenoid-free rice endosperm. Science 287 (5451), 303–305.
Zheng, Z., Henneberry, S.R., Sun, C., Nuyias Jr., R.M., 2018. Consumer demand for genetically modified rice in urban China. J. Agric. Econ. 69 (3), 705–725.