T20 Policy Brief

Task Force 6
Accelerating SDGs: Exploring New Pathways to the 2030 Agenda

BIOFORTIFICATION: A RESPONSIBLE RESEARCH AND INNOVATION STRATEGY FOR THE G20

October 2023

Krishna Ravi Srinivas, Consultant, Research and Information System for Developing Countries (RIS), New Delhi, India

P. K. Anand, Visiting Fellow, Research and Information System for Developing Countries (RIS), New Delhi, India.

Suresh Babu, Senior Research Fellow/Head of Capacity Strengthening, International Food Policy Research Institute, Washington DC, US.

वसुधैव कुटुम्बकम्

ONE EARTH • ONE FAMILY • ONE FUTURE

Abstract

Poor nutritional quality and micronutrient deficiency are major barriers to achieving goal 2 of the Sustainable Development Goals (ensuring food security and nutrition for better health), especially in developing countries, including the least developed countries. Biofortification has been widely adopted as a relevant solution with potential for expansion and diversification. New technological options such as crop genome editing and nanotechnology offer the scope to make biofortification more effective. However, biofortification cannot be a stagnant solution that can be considered a panacea. This policy brief recommends evaluating biofortification as a solution and suggests a responsible research and innovation approach to improve it continually. The brief further proposes that the G20 commits to international initiatives that consider the needs and consumer preferences in biofortification, while also localising it.

The Challenge

1

According to researcher Harold Alderman, the social and economic costs of malnutrition are substantial while "the economic returns to preventing malnutrition are on a par with those investments generally considered at the heart of economic development strategies."[1] The G20 Bali Leaders' Declaration identified malnutrition as a major issue, especially in the post-Covid-19 situation. It expressed its support to ongoing initiatives such as the Matera Declaration on Food Security, Nutrition, and Food Systems and the outcomes of the Tokyo Nutrition for Growth Summit in December 2021, including the Tokyo Compact. It also took stock of various programmes under the G20 and G7, and by international organisations like the World Bank, the International Fund for Agricultural Development, and the Food and Agricultural Organization (FAO). The State of Food Security and Nutrition in the World Report 2022 estimates that the COVID-19 pandemic has resulted in chronic undernourishment for an additional 150 million people since 2019. This situation has been exacerbated by many factors, including the ongoing conflict between Ukraine and Russia. Micronutrient deficiencies account for about 7.3 percent of the global burden of disease, while 42 percent of children less than 5 years of age and 40 percent of pregnant women worldwide are anaemic.[2] Poor nutritional quality of the food supplied, and micronutrient deficiency are major issues in ensuring food security, adequate nutrition and better health in developing countries, including least developed countries, and this has implications for the growth and all-round development of future generations. Various programmes have been launched to address this, where biofortification plays a key role. Biofortification can be defined as "an agricultural-nutrition intervention that uses conventional breeding, agronomic, and transgenic techniques to increase the density of vitamins and minerals in staple food crops."[3] Given the urgent need to achieve the Sustainable Development Goals (SDGs) and to meet the challenges in food security, adequate nutrition, and global health, biofortification is an option before the G20 that can be harnessed effectively.

The goal of SDG-2.2 is to end all forms of malnutrition. Stunting, for instance, is a barrier to fuller realisation of the human capacity and is one of the challenges to be overcome by SDG 2. Lack of vitamins and minerals in food intake enhances the risk of stunting, and it is estimated that about two billion persons are affected by this. Additionally, anaemia affects productivity and capacity for physical work. Therefore, addressing malnutrition, including anaemia, will also enable the fulfilment of SDG-1. 45 percent of children under the age of five face mortality because of malnutrition. Sufficient nutrient intake has multiple benefits, such as enhanced mental and physical productivity of the workforce. While these can be achieved in many ways, biofortification is one of the most effective methods to prevent nutritional deficiencies, as crops form the basis of the intervention. Although biofortification is an effective technical solution, its impact depends on its adoption, acceptance, delivery, affordability, and relevance. It can directly and indirectly play a key role in reaching all SDGs, particularly goals 3, 4, 5, 6, 8, and 10. According to the United Nations Conference on Trade and Development, biofortification is an important instance of applying science, technology, and innovation to achieve the SDGs. It cites high-nutrient staple crops, Vitamin A-enriched cassava, maise, orange-fleshed sweet potato, iron and zinc-fortified rice, beans, wheat, pearl millet, and quality protein maise as examples.[4]

Biofortified grains have many advantages, and they can be made part of regular dietary habits, resulting in consistent daily intake. Adoption rates can be high and sustained, particularly in the food intake of the poor, as recurring costs are low. It can also be introduced to a large section of the population through relevant interventions in food supply, public distribution, and schemes to enhance food and nutrition security. Emerging technological options, including crop genome editing and nanotechnology to develop fortified crops, open up a new range of possibilities to enhance the scope and diversity of biofortification. Globally, biofortification is being implemented on many crops and tubers. Examples of biofortification projects include iron-bio fortification of rice, beans, sweet potato, cassava, and legumes, zinc biofortification of wheat, rice, beans, sweet potato, and maise, and provitamin A carotenoid-biofortification of sweet potato, maise, and cassava. The enhancement is permanent, given that once a nutrient-enriched staple crop is developed, bred, adopted, and grown, the incremental nutrition remains the same generation after generations of cultivation. Further enhancement by developing varieties/crops with additional nutrients is also possible. Biofortification is a preferred solution for farmers because it gives them autonomy, and the resultant biofortified crops can be used to meet household needs and to sell the surpluses. Studies show that "the Copenhagen Consensus ranked interventions for reducing micronutrient deficiencies, including biofortification, among the highest value-for-money investments for economic development. For every dollar invested in biofortification, as much as US$17 of benefits may be gained."[5]

There is substantial literature on the effectiveness and efficacy of biofortification. Biofortification is a targeted approach that takes into account the needs of the population and the suitability of the technical intervention to deliver the content (see Table 1).[6]

Table 1: Breeding Targets (Parts Per Million)

	Sweet Potato	Maise	Cassava
Pro Vitamin A:			
Baseline micronutrient content	2	0	0
Additional Content Required	30	15	15
Final Target Content	32	15	15
Iron Beans Pearl Millet			
Baseline micronutrient content	50	47	
Additional content required	44	30	
Final target content	94	77	
Zinc Rice Wheat			
Baseline micronutrient content	16	25	
Additional content required	12	12	
Final target content	28	37	

Source: Howarth E. Bouis, 2018, P 72

According to Howarth E. Bouis and Amy Saltzman, it is estimated that about 150 biofortified varieties of 10 crops have been adopted in about 30 countries. Many more are at different stages of development.[7] Five approaches—agronomy, traditional plant breeding, transgenic technology, crop genome editing, and nanotechnology—have been utilised to develop biofortified crops, vegetables, and fruits. Agronomy and traditional plant breeding have already been widely tested and adopted, while crop genome editing and nanotechnology are promising emerging approaches. According to Monika Garg et al., "Although a greater emphasis is being laid on transgenic research, the success rate and acceptability of breeding is much higher."[8] Similarly, Kauser A. Mallik and Asma Maqbool point out that Golden Rice is the only example of a transgenic technology-based biofortified crop that has been adopted.[9] Regarding crop genome editing and nanotechnology, there have not yet been any instances of successful adoption of biofortified crops, tubers, or fruits.

Critical views, such as that of Caroline Hambloch et al., question some of the claims about biofortification, particularly the effectiveness and impacts of orange-fleshed sweet potato (OFSP), which is otherwise considered a successful adoption in biofortification. According to them, "whilst in the case of OFSP interventions, only a few studies determined a positive (but small) impact. It is striking that none of the OFSP studies measured the impact on the nutritional status of beneficiaries, despite it being the main impact in the ToC. OFSP studies focus mainly on outcome targets, such as adoption and vitamin A intake, falling short of measuring impact level targets, such as vitamin A adequacy and changes in dietary diversity. However, proponents of OFSP, for example, consider it to be a cost-effective intervention, particularly in Sub-Saharan Africa."[10]

They contend that interventions like OFSP, by focusing on specific nutrients, reduce malnutrition as a technical issue and ignore the larger complexities and causes of malnutrition. More often, the focus is on a single crop-based solution. Such criticism is not new, with similar views expressed by Sally Brooks in *Rice Biofortification: Lessons for Global Science and Development* in 2010.[11] These underscore an important point that technically appealing solutions need not be promoted as ideal. Arguably, if biofortification has to be adopted widely and become more relevant *inter alia*, acceptance of consumers and involvement of stakeholders is necessary.

New and emerging technical options in biofortification

Biofortification has expanded rapidly through several technological developments in the agriculture and food sectors. While traditional plant breeding was earlier used in biofortification, crop genome editing opens up new opportunities. This means that biofortification can be used quickly as crop genome editing takes much less time to develop a new crop variety or crop with a new trait vis a vis traditional plant breeding. It has been argued, for instance, that crop genome editing can be used as an alternative to enhancing β-carotene accumulation in crops.[12] Transgenic technology-based Golden Rice is the only available alternative, and it is limited to the Philippines. Using nanotechnology in biofortification is also increasingly feasible.[13] There are, however, many unresolved issues in biofortification, including those of regulation, consumer acceptance, and affordability. In this context, the following points are noteworthy:

a. Regulation of nanofoods and nanotechnology in the food sector is an emerging area with many countries yet to formulate or in the process of formulating adequate regulations. This is equally true of crop genome editing and genome-edited crops. The divergence in existing regulation ranges from de facto deregulation to treating biofortified crops as genetically modified organisms (GMOs) for regulatory purposes.

b. Despite its potential, transgenic technology has hardly been successfully adopted in biofortification. Regulation of GM crops globally is fragmented, and the divide between the US and Europe in regulating and commercialising GM crops for human consumption is still a big issue. Better public engagement in using transgenic technology for biofortification can be the preferred approach.

This policy brief argues that biofortification as a technical option is at a critical point. Even as it is more widely adopted and newer technical options emerge, a newer and better model for innovation in biofortification is needed. This new model of biofortification can overcome some of the key challenges and help innovators, policymakers, and other stakeholders to develop a socially acceptable and desirable road map for biofortification. The brief further suggests responsible research and innovation (RRI) as the preferred model for furthering innovation in biofortification. Endorsed by the European Commission, RRI is a concept and practice that places emphasis on anticipation and reflexivity. RRI aims to bridge the gap between science and society through socially relevant, sustainable, and inclusive innovation. The five core values of RRI are public engagement, open access, gender, ethics, and science education.

Although RRI may appear to be an abstract concept based on European values, it can be adopted and adapted for different technologies and in different countries/contexts. For example, in China, it has been integrated into large infrastructure projects. It is technology-neutral. Many examples of the relevance and applicability of RRI and/or RRI principles in different technologies include genome editing, synthetic biology, nanotechnology, agricultural biotechnology, and artificial intelligence.[14]

The Proposed RRI Framework for Biofortification

a) Anticipation, public engagement, and biofortification: Biofortification has its own merits and strengths in terms of technology and relevance. Nevertheless, whether it is the best option and which of the three distinct approaches to biofortification is the most suited and most acceptable is yet to be examined. Hence, inclusive debates on technological choices and policy options in the use of biofortification must be held with stakeholders. Addressing questions through debates and public engagement will be necessary to ensure that biofortification is not seen as a technology thrust upon stakeholders, including farmers and consumers, as it can comply with the norms set that are improved occasionally through RRI.

b) Inclusion and biofortification: The needs of farmers and consumers, and perceptions right from the planning for the research and development stage need to be accounted for.

Scientists should develop biofortified crops that are based on the felt needs of farmers and consumers. The needs and preferences of women as farmers and consumers must be accounted for in the development of biofortified crops.

c) Reflexivity and biofortification: Reflexivity entails going beyond the cherished assumptions about one's work, its importance/relevance, and its impactful outcomes. Regarding biofortification, the reflexivity should apply to governments, scientists, research institutions, funders, and donors. Since many biofortification projects are funded by donors and undertaken with government support, reflecting on the related assumptions and aspirations will result in greater clarity and understanding. For example, reflexivity would call for closer and perhaps critical questioning and introspection on the objectives and norms that drive the innovation process and examination of whether they are solely guided by technocratic thinking. This also requires engaging with insights from studies by social scientists, the experiences of users, and the views of stakeholders. In the case of biofortification, reflexivity, if practised objectively, can result in better assessment and consideration of other technological options and in identifying the limitations of technocratic problem-solving. It may even result in opting for a less controversial and more acceptable technological alternative in biofortification, which may not be based on cutting-edge technology. This can help in anticipating potential responses and public perception.

d) Responsiveness and biofortification: Often, biofortification is perceived as a technology based on a technocratic understanding of the problem, disregarding the societal issues and other causes for malnutrition. Transparency and building a culture of well-deliberated policymaking in decisions on biofortification can help overcome this. A policy framework for biofortification that includes the four dimensions of RRI, as discussed above, and takes into account stakeholders' views and social desirability can be developed. Linking RRI with innovation and regulatory policy in biofortification through a comprehensive framework will enhance the credibility and acceptance of biofortification as a socially desirable innovation.

The G20's Role

2

Given its commitment to addressing food insecurity and malnutrition, and its key role in attaining the SDGs, particularly SDG-2, the G20 can play a vital role in making biofortification more accessible and acceptable. Biofortification can help in achieving more than one SDG and is a time-tested technology. With new technological options arising on the horizon, it can be made more effective and used widely. Currently however in the G20 process there is no working group or forum to address biofortification, nor to synergise it with other initiatives in food and nutrition for agrifood systems. The narrow focus of global initiatives on biofortification make them inadequate to address issues of regulation, financing, and incentivising adoption of biofortification. There is no single initiative that links all biofortification initiatives as a global institutional mechanism and addresses common issues in regulation, stakeholder engagement, and consumer acceptance. While many international organisations, including the World Bank, the World Food Programme, the World Health Organization, and FAO are dealing with different aspects of biofortification, there is no inter-governmental working group or initiative on it. The opportunities and challenges from new and emerging technological options have to be addressed, but the regulatory landscape is fragmented and lacks coherence. In this context, the G20 is a prominent and committed organisation towards ensuring food security and adequate nutrition that can take a lead and provide meaningful leadership in biofortification. The G20 can then take a larger initiative involving all the G20 countries and institutions working on biofortification, by committing to convene an inter-governmental and inter-institutional working group on biofortification.

Recommendations to the G20

3

In light of the discussions above and on account of issues and concerns related to the further development and adoption of biofortification, this brief recommends the following four options for the G20 to consider. These recommendations will enhance the credibility and acceptability of biofortification, while using an RRI approach can result in innovations in biofortification that are more socially relevant. As global efforts are needed, forming an intergovernmental organisation and intergovernmental committee for regulation will be necessary. This will result in better utilisation and regulation of biofortification technologies. This will also spur further innovation in technologies and policies.

- Assessment of biofortification by studying the ethical, social, and legal issues.
- Using the RRI approach to advance science, technology, and innovation with strategies for better acceptance.
- Encouraging the establishment of an international institution on biofortification.
- Encouraging the development of an intergovernmental committee for regulatory systems with respect to biofortification.

Attribution: Krishna Ravi Srinivas, P.K. Anand, and Suresh Babu, "Biofortification: A Responsible Research and Innovation Strategy for the G20," *T20 Policy Brief,* October 2023.

Endnotes

1 Harold Alderman, “The economic cost of a poor start to life”, *Journal of Developmental Origins of Health and Disease,* 1(1), Feb 2010: 19-25. doi: 10.1017/S2040174409990158.

2 Olson, Rebecca, Breda Gavin-Smith, Chiara Ferraboschi, and Klaus Kraemer, “Food Fortification: The Advantages, Disadvantages and Lessons from Sight and Life Programs” Nutrients 13, no. 4: 1118. 2021 https://doi.org/10.3390/nu1304111

3 Michaux Kristina, “Biofortification: A food-based strategy to help reduce the disease burden associated with iron deficiency”, https://cdn.who.int/media/docs/default-source/anaemia/areacop-webinar---24-september-2020/areacop-webinar-kristinamichaux-presentation.pdf?sfvrsn=45bc32a3_6

4 United Nations Conference on Trade and Development, *The role of science, technology and innovation in ensuring food security by 2030 Geneva*, Geneva, 2017.

5 Howarth E. Bouis, and Amy Saltzman, “Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016”, *Global Food Security,* March 2017: 49-58, doi: 10.1016/j.gfs.2017.01.009.

6 Howarth E. Bouis, “Biofortification: An Agricultural Tool to Address Mineral and Vitamin Deficiencies”, In *Food Fortification in a Globalized World*, Edited by M.G. Venkatesh Mannar, Richard F. Hurrell London: Academic Press, 2018, 69-81.

7 Howarth E. Bouis, and Amy Saltzman, “Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016”, *Global Food Security,* March 2017: 49-58, doi:10.1016/j.gfs.2017.01.009.

8 Monika Garg, Natasha Sharma, Saloni Sharma, Payal Kapoor, Aman Kumar, Venkatesh Chunduri, and Priya Arora, “Biofortified Crops Generated by Breeding, Agronomy, and Transgenic Approaches Are Improving Lives of Millions of People around the World”, *Frontiers in Nutrition*, 5 February 2018: 12, doi:10.3389/fnut.2018.00012.

9 Kauser A. Malik and Asma Maqbool, *“Transgenic Crops for Biofortification”, Frontiers in Sustainable Food Systems,* 4 November 2020: 571402, doi:10.3389/fsufs.2020.571402.

10 Caroline Hambloch, Kai Mausch, Costanza Conti, and Andy Hall, “Simple solutions for complex problems? What is missing in agriculture for nutrition interventions”, *Food Security,* 15, April 2023: 363-79, https://doi.org/10.1007/s12571-022-01324-6 p 370.

11 Sally R. Brooks, *Biofortification: Lessons for Global Science and Development* (London: Routledge, 2010), https://www.taylorfrancis.com/books/mono/10.4324/9781849776486/rice-biofortification-sally-brooks.

12 Akira Endo, Hiroaki Saika, Miho Takemura, Norihiko Misawa and Seiichi Toki, “A novel approach to carotenoid accumulation in rice callus by mimicking the cauliflower *Orange* mutation via genome editing”, *Rice,* 12 November 2019: 81, https://doi.org/10.1186/s12284-019-0345-3.

13 Mohammad K. Khan, Anamika Pandey, Mehmet Hamurcu, Sait Gezgin, Tabinda Athar, Vishnu D. Rajput, Om P. Gupta, and Tatiana Minkina, “Insight into the Prospects for Nanotechnology in Wheat Biofortification”, *Biology*, 10 November 2021: 1123, https://doi.org/10.3390/ biology10111123.

14 Saori Ishizu, Mizuki Sekiya, Ken-ichi Ishibashi, Yumi Negami, and Masafumi Ata, “Toward the responsible innovation with nanotechnology in Japan: our scope”, *Journal of Nanoparticle Research,* 15, October 2008:229-54, https://doi.org/10.1007/s11051-007-9306-7.

भारत 2023 INDIA

INDIA 2023

वसुधैव कुटुम्बकम्

ONE EARTH • ONE FAMILY • ONE FUTURE