AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 02, Issue: 12 (December, 2025)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

Biofortification in Fruit Crops: Enhancing Nutrition Naturally

*Umesh Kumar Chanderia, Khushi Verma, Deepak Singh,
Raushan Verma and Ajay Singh
Department of Horticulture, JNKVV, Jabalpur (M.P.)-482004, India
*Corresponding Author's email: ukchanderia@jnkvv.org

Biofortification in fruit crops is a significant pathway to enhance the nutritional value of fruits by increasing concentrations of prerequisite micronutrients that are minerals as well as vitamins by agricultural methods, traditional breeding, or new biotechnological technique. The primary objective is to address micronutrient deficiencies and "hidden hunger"—widespread malnutrition that affects vulnerable populations, especially in developing regions where access to diverse, nutrient-rich foods is limited.

What is biofortification?

The Latin word "fortificare" means "make strong," while the Greek word "bios" means "life". The process of improving food crops nutritional value using agronomic techniques, traditional plant breeding, or contemporary biotechnology is known as biofortification. In contrast to conventional fortification, biofortification attempts to raise the nutritional levels in crops while they are growing rather than by hand after agricultural processing.

Examples

Pomegranate (*Punica granatum* L.): A biofortified hybrid variety called Solapur Lal was developed with higher iron, zinc, and vitamin C content than traditional varieties. It matures earlier and yields more fruit with enhanced nutritional quality.

1. Guava (*Psidium guajava* L.): Conventional breeding and genetic engineering have been employed to increase vitamin C, beta-carotene, iron, and zinc in guava. The Paluma cultivar is known for its high antioxidant content and nutritional benefits.
2. Mango (*Mangifera indica* L.): Traditional breeding has been used to enhance mineral content such as iron and zinc. Genetic engineering has also aimed to increase beta-carotene levels, and micronutrient application improves fruit quality.
3. Banana (*Musa acuminata* Colla): A transgenic banana variety called "Super Banana" was developed with increased beta-carotene content through expression of a PSY gene. It ranks as an important crop for food security in developing countries.

Techniques

Biofortification in fruit crops involves increasing the nutritional value of fruits through various methods. The main techniques include:

1. Agronomic Biofortification: This involves applying mineral fertilizers (such as zinc, iron, calcium) to the soil or as foliar sprays to increase nutrient concentration and bioavailability in the fruits. This method focuses primarily on minerals rather than vitamins and is often combined with other strategies to be more effective.
   Example: Banana (foliar spray of $ZnSo_4 7H_2O$ in pseudo stem @ 1, 2 and 4%) Guevara *et al*., 2021
2. Conventional Plant Breeding: Selection and breeding of fruit varieties with naturally higher nutrient contents using genetic differences within species. This can enhance

minerals, vitamins, antioxidants, and other beneficial compounds in fruits over successive breeding cycles.

Ex: Aonla (NA-7),Vitamin C(Trait) Iqbal et al., 2015

3. Biotechnological Approaches:

- Marker-Assisted Breeding (MAB): Uses molecular markers to select traits for enhanced nutrient content quickly.
- Genetic Engineering: Introduction of specific genes to boost nutrient synthesis or accumulation, e.g., increasing iron, zinc, beta-carotene levels.
- Genome Editing Techniques (CRISPR/Cas9, ZFN): Precise modification of genes to improve nutrient profiles without introducing foreign DNA.
- RNAi Technology: Used to develop disease-resistant plants with improved growth and nutrient content.

Ex: Banana PSY2a (Gene involved/Variety),Beta-carotene Waltz, 2014

4. New Plant-Breeding Techniques (NBTs):

- Cisgenesis and Intragenesis for gene transfer within related species.
- RNA-dependent DNA Methylation (RdDM) to regulate gene expression enhancing nutrient production.
- Grafting techniques combining improved rootstocks with non-GM scions to boost nutrient uptake.

5. Omics Technologies: Integrating genomics, transcriptomics, and metabolomics tools to identify and manipulate genes linked to nutrient biosynthesis pathways for more effective biofortification.

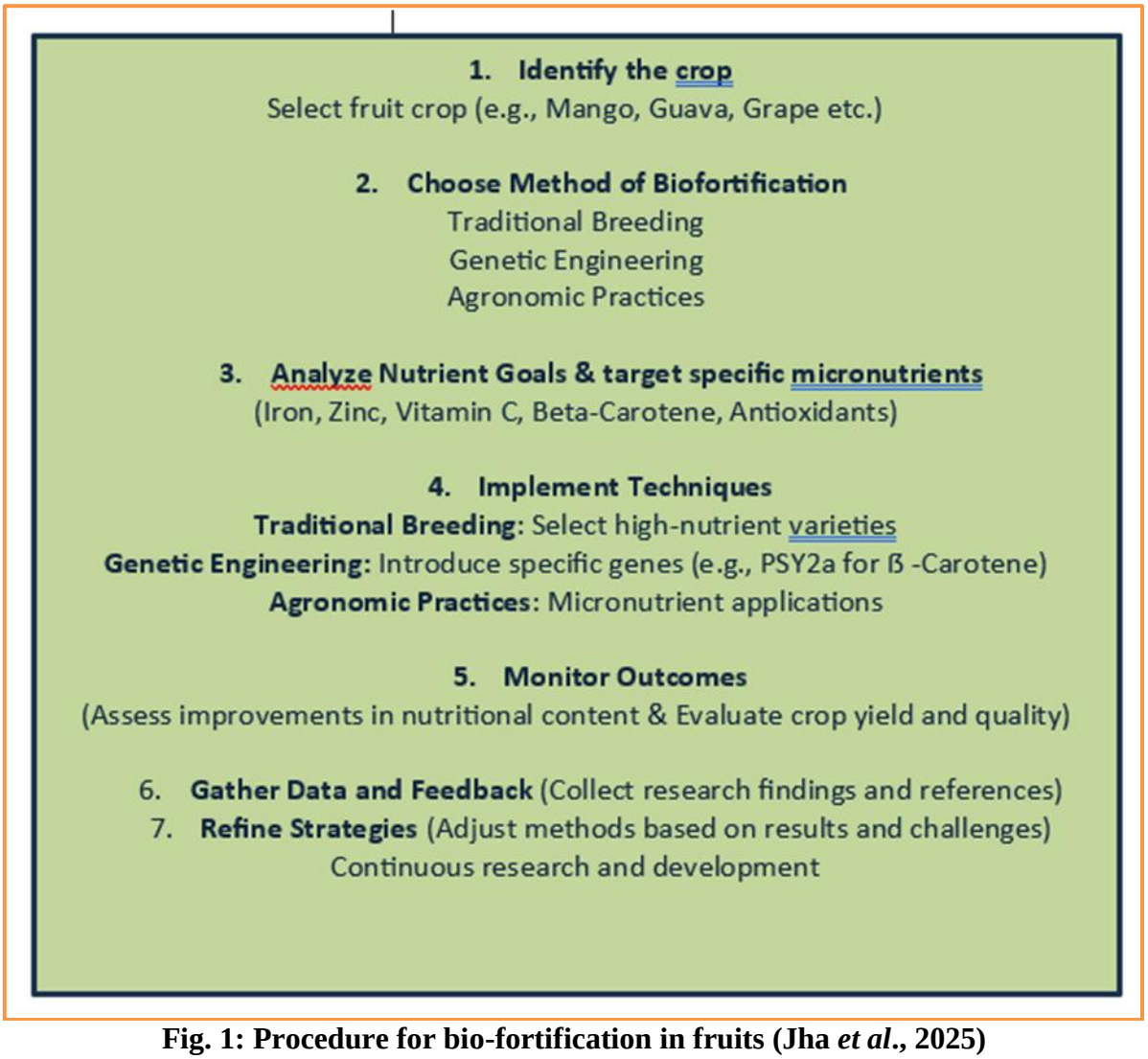

Fig. 1: Procedure for bio-fortification in fruits (Jha *et al.*, 2025)

Challenges and ethics

Biofortification in fruit crops faces several challenges and ethical considerations.

- Challenges include identifying suitable microbial strains for biofortification, environmental variability affecting effectiveness, and technical difficulties in breeding for nutrient stability and bioavailability.
- Consumer acceptance issues arise due to altered appearance or taste of biofortified fruits and lack of awareness about benefits.
- Regulatory hurdles exist for genetically modified biofortified fruit crops.
- Ethical concerns focus on equitable access, potential dependency on proprietary technologies, and transparency about genetic modifications.
- Successful scale requires upgraded local supply chains, community engagement, and addressing socio-economic disparities.

Conclusion: Nutritious fruits for a healthier future

Biofortification in fruit crops plays a pivotal part in delivering nutritious meal for a healthier future. By enhancing essential vitamins, minerals, and antioxidants through traditional breeding, genetic engineering, and agronomic practices, biofortified fruits help combat malnutrition and hidden hunger, especially in vulnerable populations. These nutrient-rich fruits support proper growth, development, and disease resistance, contributing to better public health and economic growth globally. Advances in new plant-breeding techniques promise more sustainable and efficient production of nutrient-dense fruits, thus ensuring food security and improved nutrition for future generations.

References

1. Guevara, J.E.M., Sanches, A.G., Pedrosa, V.M.D., Cruz, P.M.C., Silva, J.A.A. and Teixeira, HAD. (2021). The injection of zinc sulfate into banana tree pseudostem can triple the zinc content and it is an effective method for fruit biofortification. *Journal of Food Composition and Analysis*, 102:104020.
2. Iqbal, M., Bakshi, P., Kumar, R., Wali, V.K. and Bhushan, B. (2015). Influence of mulching on fruit quality of aonla (*Emblica officinalis* Gaertn.) cv. NA-7. *Ecology Environment and Conservation*, 21(3): 263-268.
3. Jha, A., Jayswal, D.K., Shikha, D., Kumar, A. and Ahmad, F. (2025). Empowering vital fruit crops with enhanced nutritional contents. *Frontiers in Plant Science*, 16: 1-17.
4. Waltz, E. (2014). Vitamin A Super Banana in human trials. *Nature Biotechnology*, 32: 857.