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Biofortification in Vegetable Crops

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Abstract

Approximately 800 million people suffer from hunger globally, but an even larger number grapple with micronutrient malnutrition, often termed "hidden hunger." This issue is particularly prevalent in developing countries. Deficiencies in iodine, vitamin A, iron, and zinc pose significant health concerns. In countries like India, where cereal-based diets dominate and access to fruits and vegetables is limited, malnutrition related to minerals (Fe, Zn) and vitamin A remains a primary health challenge. To address this, biofortification emerges as a promising solution. Biofortification involves breeding essential nutrients directly into food crops, offering a cost-effective, sustainable, and long-term approach to deliver vital micronutrients to rural populations in developing nations. Biofortification offers a straight forward solution to intricate nutritional disorders. It involves adding nutrients to commonly consumed crops, ensuring a long-term and sustainable delivery of essential micronutrients. Biofortification of commonly consumed food crops offers the simplest solution to complex nutritional disorders. Biofortification is the process of adding nutrients to food crops, which provides a sustainable and long term means of delivering more micronutrients.

Keywords: Biofortification, malnutrition, nutrition

Introduction

Biofortification is derived from two words, i.e., "bio," derived from the Greek word for life, and "fortificare," from the Latin word meaning to make strong. It signifies the enrichment of crops with nutrients to combat the adverse economic and health effects of vitamin and mineral deficiencies in humans (Vandana *et al*., 2022). Biofortification involves enhancing the nutritional quality of food crops. This can be achieved through various methods, including agronomic practices, traditional plant breeding, and modern biotechnology (Bouis and Saltzman, 2017). The primary objective is to boost the concentration of essential vitamins and minerals in crops. By doing so, biofortification aims to combat dietary deficiencies, such as anemia and immune system impairments, ultimately improving public health. In vegetable crops, the focus is on increasing nutrients like iron, zinc, and vitamins (A, C, D & E) to benefit the population's well-being (Gomathi *et al*., 2019).

Criteria of biofortification

- Efficacious bioavailability
- Consumer acceptance
- Crop productivity must be high
- Micronutrient enrichment must be effective
- Must be stable

Techniques in Biofortification of Vegetable Crops

Agronomic Practices: Agronomic practices involve applying fertilizers containing micronutrients or optimizing soil pH and fertility to enhance the nutrient content of crops. For instance, using zinc or selenium-enriched fertilizers can increase the mineral content, benefiting vegetables' nutritional value.

Conventional Breeding: It refers to the process of crossing plants with desirable traits over multiple generations to enhance specific nutrients. For example, scientists selectively breed various sweet potato varieties to increase their beta-carotene content, which serves as a precursor for vitamin A.

Genetic Engineering: This method directly modifies the genetic makeup of vegetables to enhance nutrient levels. A notable example is Golden Rice, which has been genetically modified to produce beta-carotene, the essential precursor for vitamin A (Athar *et al*., 2020).

Biofortification emerges as a strategic weapon in the global fight against malnutrition, especially micronutrient deficiencies that impact over two billion people worldwide. This approach, aimed at enhancing the nutritional quality of food crops, brings forth several noteworthy advantages:

1. Combatting Micronutrient Deficiencies: Micronutrient deficiencies, often termed as "hidden hunger," result from insufficient intake of essential vitamins and minerals like vitamin A, iron, and zinc. These deficiencies can lead to severe health consequences, including impaired immune function, blindness, premature mortality, and, in the case of iron deficiency, anemia. Biofortification plays a crucial role in enhancing nutrient intake through daily diets, thereby combating these health challenges.

2. Cost-Effectiveness: Biofortification stands out as a cost-effective approach compared to other nutritional interventions. Once biofortified varieties are developed and seeds are distributed to farmers, the enhanced traits persist in the crops without necessitating continuous investment. This sets it apart from food fortification or supplementation programs, which rely on ongoing funding and infrastructure**.**

3. Reach and Scalability: Biofortified crops play a crucial role in reaching rural populations who often face challenges accessing commercially fortified foods, dietary supplements, or diverse diets due to geographic and economic constraints. The wide reach of biofortification makes it particularly valuable for remote and underserved areas.

4. Sustainability: Biofortification leverages existing agricultural and food systems to enhance nutrition. By doing so, it minimizes the requirement for additional resources and reduces environmental impact. This approach aligns seamlessly with sustainable agricultural practices, as it boosts nutritional output without necessarily expanding inputs or cultivation area.

5. Empowerment Through Agriculture: Biofortification, being an integral part of crop production, empowers farmers. It enables them to cultivate nutrient-rich crops that enhance not only their own family's diet but also benefit their entire communities. This has the potential to improve health outcomes across the community, boost productivity, and reduce healthcare costs.

6. Long-term Health Benefits: Increasing the nutritional value of staple crops that people consume daily can lead to significant improvements in public health. For example, vitamin A-rich crops reduce the severity of infections in children and decrease mortality rates. Iron-rich crops can improve cognitive function and reduce the impact of anaemia on women and children.

7. Consumer Acceptance: Biofortified crops usually maintain the same taste and appearance as their non-biofortified counterparts. This similarity is crucial for their acceptance by local communities. Additionally, these crops typically do not necessitate alterations in cooking methods or eating habits, making their adoption seamless.

8. Support for Local Biodiversity: Biofortification initiatives play a crucial role in biodiversity preservation. They achieve this by promoting the cultivation of diverse crop species that are either naturally abundant in specific nutrients or have been selectively bred to enhance particular micronutrients.

Biofortified vegetable crops

Cauliflower

Pusa Betakesari

- Country's first provitamin-A rich cauliflower
- Rich in provitamin-A (8.0-10.0 ppm) in comparison to negligible content in popular varieties
- Curd yield: 40.0-50.0 t/ha

Purple Sicily

- It's a colourful, cool-season heirloom variety belonging to the Brassicaceae family.
- It contains anthocyanin.

Pusa Betakesari

Purple Sicily

Potato

Kufri Manik

- Rich in anthocyanin (0.68 ppm) in comparison to negligible content in popular varieties, High in antioxidants.
- Tuber yield: 23.0 t/ha; Maturity: 90-100 days

Bhu Sona

- Rich in provitamin-A (14.0 mg/100g) in comparison to 2.0-3.0 mg/100g in popular varieties
- Tuber yield: 19.8 t/ha
- Dry matter: 27.0-29.0 % ; Starch: 20.0 %; Total sugar: 2.0-2.4%

Kufri Neelkanth

- Rich in anthocyanin (1.0 ppm) in comparison to negligible content in popular varieties, High in antioxidants
- Tuber yield: 36-38 t/ha; Maturity: 90-100 days

Kufri Manik

Bhu Sona

Kufri Neelkanth

Okra

Kasha lalima

- Reddish purple fruits
- Medium tall and short internodes with fruit yield of 14-15 t/ha.
- Rich in anthocyanin and phenolics.
- Suitable for both summer and Kharif season.

Kasha lalima

Cabbage

Kinner Red

- Anthocyanin rich cabbage.
- Heads are red in colour.
- Tolerant to diamond back moth.
- It has distinct coat of wax and produces a head of 1-2 kg, taking about 90 days from transplanting to head formation.

Kinner Red

Conclusion

In the current situation, hunger and malnutrition present significant challenges in our current context. However, we can address these issues through nutrient-rich biofortified vegetables, which offer long-term benefits. Notably, biofortification is both environmentally advantageous and economically viable. By raising awareness about the benefits of various vegetables, we can prevent and manage many health problems. The most practical approaches for enhancing the nutritional quality of vegetable crops include agronomic biofortification, conventional breeding, and transgenic techniques.

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