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Biofortification - Means of Nutritional Enrichment

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Abstract

While the Green Revolution successfully addressed the issue of food security in developing nations like India and significantly improved productivity, it has not been able to bring about the same level of dietary diversity as seen in developed nations. More than two billion people throughout the world suffer from micronutrient deficiency alone. Micronutrient malnutrition is presently regarded as the most critical danger and worldwide obstacle facing humanity. The strategy of biofortification is a developing method to tackle the issue of micronutrient malnutrition. By enhancing the nutritional value of food crops by the use of biotechnology, traditional plant breeding, and agronomic methods, it is possible to increase the bioavailability of their nutrients to humans who consume them. This paper focuses on micronutrients' importance, micronutrient deficiency symptoms, biofortification strategies, and agronomic biofortification.

Keywords: Biofortification, Malnutrition, Micronutrients, Tackling hidden hunger

Introduction

Inadequate or excessive food intake, an unequal distribution of vital nutrients, or poor nutrient utilisation is the hallmarks of malnutrition. Undernutrition, overweight, and obesity are all included in the double burden of malnutrition, which also includes dietary-related non-communicable illnesses. The four primary manifestations of undernutrition are stunting, wasting, being underweigh, and micronutrient deficiencies.

Low weight for height is the defining characteristic of wasting, which typically indicates recent and severe weight loss, but can also persist over time. This condition usually arises due to insufficient quality or quantity of food intake and/or frequent or prolonged illness. If left untreated, wasting in children can increase their risk of mortality. On the other hand, stunting results in low height for age and is characterised by chronic or recurring under nutrition, which is frequently connected to poverty, poor maternal health and nutrition, frequent sickness, and/or unsuitable feeding and care throughout early life. Stunting can limit a child's potential for physical and intellectual growth. Low weight for age is considered to be underweight and a kid that is underweight may also experience stunting, wasting, or both.

Importance of Micronutrients

Iron (Fe) is a crucial micro-mineral nutrient in the human body, serving as a vital component of hemoglobin, which plays a crucial role in the transport and storage of oxygen. Approximately 85% of the iron in the human body is contained in two hemoproteins: hemoglobin, responsible for transporting oxygen from the lungs to various parts of the body, and myoglobin, which stores oxygen in muscles.

- Irreversible blindness can occur as a result of inflammation and infection.
- Reproductive disorders and growth retardation can be linked.
- Individuals who are malnourished may be more susceptible to illnesses such as measles, respiratory diseases, and diarrhea.

Biofortification

Micronutrients including vitamin A, zinc, and iron are crucial to overcoming this shortage, as seen in figure 1. Utilising cutting-edge biotechnology, conventional plant breeding techniques, and agricultural practises, the biofortification programme attempts to improve the nutritional content of food crops and boost their bioavailability to people. The programme is now concentrating on raising the amounts of certain micronutrients in these crops.

Biofortification is the process of genetically enhancing

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Figure 1: Micronutrient enrichment of biofortification

essential food crops to increase their nutrient content, which distinguishes it from fortification, where external nutrients are added (such as in iodized salt). The primary objective of biofortification is to enhance the nutrient levels of crops directly at the source through agricultural interventions, such as agronomy, breeding, and biotechnology techniques.

Global micronutrient deficiency is being addressed through the agricultural method known as biofortification. By implementing biofortification techniques, the number of individuals suffering from micronutrient deficiencies will be reduced, thereby decreasing the need for more expensive interventions such as supplementation and fortification programs.

Methods of Biofortification

Biofortification is a very feasible and cost-efficient approach. It is easier to deliver the necessary micronutrients to large populations of developing countries. There are three ways to apply biofortification to plants. The process of achieving biofortification involves a combination of agricultural practices, plant breeding, and genetic engineering.

The three primary biofortification techniques of biofortification methods are listed here below.

Selective Breeding of Plants

This technique uses the breeding methods of plants in a traditional way. The genetic variations are sufficiently produced for a particular trait that is desired. Crossing various breeds of plants over many generations is done. It finally yields a plant with high nutrients. This is the only technique that is followed in India. The biotechnology field is also used in this approach to aid in breeding programs, like the molecular marked-assisted segment. This approach increases the breeding success significantly to improve the nutritional value of the plants.

Genetic Modification

This technique uses a DNA genome of an organism to insert the desired characteristic. This approach of genetic engineering is preferred over conventional breeding techniques. This is because genetic engineering can produce new varieties faster. This method uses advanced biotechnology concepts. The target of genetic engineering is:

• Enhance efficiency.

• Reduce the presence of anti-nutritional compounds in the soil.

• Enhance the accessibility of nutritional compounds.

Agronomic Practices

All humans rely on agriculture as the source of minerals and nutrients, especially for the developing country population. Staple Foods is a primary dietary source in most countries. These foods are deficient in many vitamins and micronutrients. The agronomic practice of biofortification is a way to improve the mineral, vitamin, and micronutrient contents. This method uses fertilizers to improve the number of micronutrients in plants through agronomic practices as mentioned in figure 2. It is used in soil conditions that are deficient in these micronutrients and minerals.

Figure 2: Biofortification through agronomic approach

This biofortification method uses fertilizers with micronutrients so that the plant takes the micronutrient. To increase the quantities of micronutrients in the edible parts of food crops, micronutrient-containing mineral fertilizers are given to the soil and/or leaves of plants (White and Broadley, 2009).

The plant also uses these micronutrients for various plant functions. There is an addition of bacteria such as plant growth-promoting bacteria (PGPB) to the agricultural soil. The effectiveness of this method lies in its ability to improve the quality of agricultural soil through the reintroduction of beneficial microbes. These microbes play a vital role in facilitating nutrient assimilation, boosting water absorption, and promoting plant growth by releasing hormones and antibiotics.

This method is a cost-efficient and quick solution to fix the soil. By making micronutrients more accessible to plants and enhancing the nutritional value of crops, this technique aids in preserving soil fertility. It is particularly beneficial for crops like sorghum, maize, cassava, and millet.

Good management of field nutrients has a positive ecological and economic impact. It also improves the availability of micronutrients. This practice is relatively new and used for a few nutrients, such as zinc and iodine. It did not succeed with nutrients such as iron. The success of this method depends on the geographical location where it is practiced.

Tackling 'Hidden Hunger'

Micronutrient deficiencies or unrecognised hunger can impede the growth and development of both crops and people. Micronutrient deficiency in the soil can influence agricultural yield and food quality, both of which have an impact on human health and nutrition. Numerous soils in sub-Saharan Africa have deficiencies in a variety of nutrients, including zinc, iron, copper, manganese, molybdenum, and boron (B), as well as macronutrients like nitrogen (N), phosphorus (P) and potassium (K), secondary nutrients like sulphur (S), calcium (Ca), and magnesium (Mg), and micronutrients like sulphur (S). In this location, where 75% of the arable land suffers from severe soil fertility problems, soil micronutrient deficits are particularly severe. Low crop yield is caused by the lack of micronutrients in the soil.

Diets in sub-Saharan Africa are frequently undiversified and largely dependent on staples, including maize, rice, cassava, sorghum, millet, bananas, and sweet potatoes, especially in households with minimal resources. This results in a shortage of essential micronutrients such as minerals and vitamins, leading to widespread micronutrient deficiencies. Especially for women and small children, a chronic micronutrient shortage can have serious health effects and frequently goes unreported, giving rise to the term "hidden hunger."

Multiple micronutrient deficiencies are prevalent among many individuals. For instance, in Malawi, over 50% of households are at risk of deficiencies in calcium, zinc, and/or selenium. Although not essential for plant growth, selenium can be obtained by humans through consuming crops that have absorbed the mineral from the soil. Micronutrient deficiencies, even mild to moderate ones, can cause serious health problems such as impaired metabolic function, lower immunity, increased susceptibility to infections, growth failure, cognitive decline, and decreased productivity. In conclusion, we analyze the potential and challenges of implementing agronomic biofortification as a solution in sub-Saharan Africa.

Hidden hunger can be addressed by direct (nutrition-specific) and indirect (nutrition-sensitive) therapies. Direct treatments, which include tactics like dietary diversification, micronutrient supplementation, food fortification, and altering food preferences, attempt to change consumption behaviour. On the other hand, nutrition-sensitive interventions tackle the root causes of malnutrition and may involve approaches such as biofortification (Sazawal *et al.*, 2018).

According to Bouis *et al*. (2011), biofortification is the process of combining genetic and agronomic techniques to increase the amount and/or bioavailability of vital nutrients in crops during growth (Sazawal *et al.*, 2018). Agronomic biofortification includes adding micronutrient fertilizers directly to the crop's leaves or to the soil, whereas genetic biofortification uses genetic engineering or conventional breeding method. This is due to the fact that these crops are commonly consumed worldwide, particularly among populations at risk of micronutrient deficiencies. Moreover, these crops provide a practical solution for reaching malnourished communities that have limited access to diverse diets, supplements, and commercially fortified foods.

Advantages

- Biofortification employs the multiplier effect of breeding research across different locations and periods of time.
- Biofortification is a sustainable approach as it is one-time investment and incurs lower recurrent costs for development.
- Biofortification is accessible to rural populations rely on locally produced staple foods for their consumption.
- Biofortification targets low-income groups who may not have the financial means to access a diverse range of nutritious foods for a balanced diet.
- Biofortification is easily adoptable in field conditions.

SWOT Analysis

Strength

- Biofortification is a more cost-effective and sustainable approach.
- Biofortification has a wider reach and is replicable over a large scale.
- Improved bioavailability and efficacy.
- Nutrients embedded naturally.
- Biofortified crops exhibit more resilience to pests, diseases, and droughts, and generally have higher yields.

Weakness

- Implementing biofortification in India is challenging due to the prevalence of marginal farming.
- Low awareness among the masses.

Opportunities

- Growing demand from commercial/ non-commercial segments.
- Since process costs are minimal, supply chain efficiency is paramount.
- Suggested for consumer segments with a focus on health and wellness.
- A way for food companies to differentiate their products from competitors.

Threats

- Opposition to implementation because of the perceived risk around biotechnologically engineered crops.
- The lack of traceability in the value chain can lead to adulteration.
- Non-availability of biofortification standards to facilitate grain trade.
- Adequate nutrient testing laboratories and infrastructure are lacking.

Conclusion

A cost-effective agriculture method called biofortification has the potential to substantially enhance the nutritional status of impoverished communities all over the world. To boost the nutritional content of crops, this strategy uses targeted genetic modification, crop breeding, and/or the application of mineral fertilizers. This can help address mineral malnutrition in humans by providing sufficient levels of micronutrients like iron, zinc, selenium, and provitamin A which are frequently lacking in the diets of both developing and developed countries. International initiatives like the Harvest Plus program and national initiatives are working towards achieving these targets, resulting in biofortified crops with improved nutrient contents. However, biofortification is a difficult process that calls for cooperation amongst molecular biologists, genetic engineers, nutritionists, and plant breeders. Traditional breeding-based methods have had greater success than transgenic ones since transgenic crops have difficulty gaining consumer acceptability and must go through expensive and drawn-out regulatory approval procedures. In spite of these difficulties, biofortified crops have a tremendous potential to reduce micronutrient deficiency in low-income populations, especially in emerging nations.

References

Bouis, H.E., Hotz, C., McClafferty, B., Meenakshi, J.V., Pfeiffer, W.H., 2011. Biofortification: a new tool to reduce micronutrient malnutrition. *Food and Nutrition Bulletin* 32(1 Suppl), S31-S40. DOI: https://doi.org/10.1177/15648265110321S105.

Sazawal, S., Dhingra, U., Dhingra, P., Dutta, A., Deb, S., Kumar, J., Devi, P., Prakash, A., 2018. Efficacy of high zinc biofortified wheat in improvement of micronutrient status, and prevention of morbidity among preschool children and women - a double masked, randomized, controlled trial. *Nutr. J.* 17, 86. DOI: https://doi.org/10.1186/s12937-018-0391-5.

White, P.J., Broadley, M.R., 2009. Biofortification of crops with seven mineral elements often lacking in human diets - iron, zinc, copper, calcium, magnesium, selenium and iodine. *New Phytologist* 182(1), 49-84. DOI: https://doi.org/10.1111/j.1469-8137.2008.02738.x.