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BIOFORTIFICATION OF NUTRIENT-EDIBLE CROPS"

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Abstract:-

Achieving the UN Sustainable Development Goal of eradicating all forms of hunger by 2030 is a formidable yet imperative challenge, given the constrained timeline and the adverse global repercussions of hunger on health and socio-economics. Approximately one-third of the global population suffers from malnutrition or hidden hunger due to micronutrient deficiencies, posing a severe hindrance to economic progress. This has prompted numerous nations to create solutions that could aid in the fight against malnutrition and covert hunger. Food supplementation and dietary diversity are two interventions that are being used. However, the most effective fortification, particularly biofortification, has been predicted to lasting remedy for unmet hunger and malnutrition. To address this issue, the strategy of fruit crop biofortification through gene stacking, employing a judicious blend of traditional breeding and metabolic engineering techniques, holds the potential for significant progress in the next decade. To realize this goal, several specific actions and policy measures are recommended. These measures are vital in our collective pursuit of ending hunger, enhancing global health, and fostering economic development by 2030 as outlined in UN-SDG2. This review article highlights recent research findings and the progress made in expanding biofortification to new countries and environments, thus addressing the global challenge of malnutrition.

Keywords: Biofortification, Hidden hunger, Malnutrition, Edible crop.

Introduction:

Background: -

According to recent FAO estimates, nearly 690 million people in the World are hungry (FAO, IFAD, and WFP, 2020). Globally, the burden of malnutrition in all its forms remains a challenge 144 million children under 5 years of age were stunted, 47 million wasted, and 38.3 million overweight One form of malnutrition is expressed in micronutrient deficiencies. Micronutrient deficiencies afflict more than two billion individuals, or one in three people globally, causing weakened immune systems and avoidable health outcomes, including

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blindness, delayed growth, and cognitive and physical development. Humans require various nutrients (vitamins and minerals) in adequate amounts to live healthy and productive lives. Of these nutrients, four are in chronically short supply among economically disadvantaged communities: iron, zinc, iodine, and vitamin A. Shortage of these micronutrients can have significant consequences on human health and development, causing a wide range of physiological impairments, leading to reduced resistance to infections, metabolic disorders, and delayed or impaired physical and psychomotor development. Because of societal and health implications of micronutrient d efficiencies, there is a heightened interest within development institutions, governments, NGOs, and the scientific community in the need to seek solutions to addressing micronutrient deficiencies. Different approaches are being put forward to tackle micronutrient deficiencies. These include diet diversification, biofortification, food fortification, and supplementation.

Biofortification?

Biofortification gathers different processes and methods to increase the density of vitamins and minerals in the edible parts of the crops, or reduce anti-nutrients, to improve the nutritional quality of the food supply. Some stakeholders and promoters of biofortification believe that focusing on genes coding for essential nutrients is a promising route for addressing micronutrient deficiencies in developing countries. Some others consider it a 'false solution' that is risky, expensive, and short-term.

There are currently three main methods associated with biofortification: -

1 **Conventional biofortification uses conventional breeding techniques**, i.e., the development of new varieties (cultivars) of plants by using natural selection to improve a desired genetic trait of a given crop variety.
   - It is about manipulating plant genomes within the natural genetic boundaries of the species.

2 **Agronomic biofortification**: - through direct fertilization of the soil with essential minerals or pulverization on the crop leaves.

3 **Biofortification using new genetic engineering techniques: -** at directly introducing desired genes, and related micronutrient-dense traits, into a host genetic code, thus modifying it.

Current biofortification initiatives-

Biofortification initiatives are being developed and implemented through the international alliance of HarvestPlus3 to improve Iron, Zinc, and Vitamin A status among lower-middle income populations; a few key players dominate the market of biofortification and those promoters of biofortification produce the most available literature about experiments. Several biofortification initiatives are ongoing around the world covering different food crops and targeted micronutrients. Staple foods recognized as vehicles for the biofortification of specific micronutrients and targeted countries are given in Table 1. below (Siwela et al., 2020).

malnutrition and its potential to effectively complement other strategies (such as food fortification, food supplementation, and food diversification) seems to have convinced governments.

Status of malnutrition: -

Malnutrition contributes to increased morbidity, and disability, stunted mental and physical growth, and reduced national socio-economic development.

Table 1. Biofortification: targeted micronutrients, staple crops and countries

Target micronutrients	Staple crops	Targeted country
Vitamin A Orange-fleshed	sweet potato	South Africa, Uganda,
Vitamin A	Maize	Nigeria, Zambia
Vitamin A	Cassava	DRC, Nigeria
Iron	Common Bean	DRC, Rwanda
Iron	Pearl millet	India
Zinc	Wheat	India, Pakistan
Zinc	Rice	India, Bangladesh

In the past 20 years, the biofortification strategy has received considerable scientific and market attention as it is presented with promising arguments as a new way to end hunger in the world. As such agricultural research organizations have made biofortification a priority and donors are investing a lot of funds in this area, but, without necessarily the promising results from such investment. Globally, biofortified crops have been released in 40 countries, covering Africa, Asia, and Latin America. The argument that it is an inexpensive way to fight

The extent of malnutrition worldwide as well as in India is presented below.

Global scenario:

- Two billion people suffer from micronutrient deficiency or 'hidden hunger'
- 820 million people are undernourished.
- 149 million (21.9%) children (<5 years) are stunted.
- 49.5 million (7.3%) children (<5 years) possess wasting.
- Nearly 45% of deaths among children (<5 years) are linked to malnutrition.

S.N.	Crop	Nutrient	Baseline levels	Levels achieved
1	Rice	Protein	7.0-8.0 %	>10.0 %
		Zinc	12.0-16.0 ppm	>20.0 ppm
		Protein	8-10 %	>12.0 %
2	Wheat	Iron	28.0-32.0 ppm	>38.0 ppm
		Zinc	30.0-32.0 ppm	>37.0 ppm
3	Maize	Provitamin-A	0.5-1.5 ppm	>5.0 ppm
		Lysine	1.5-2.0 %	>2.5 %
		Tryptophan	0.3-0.4 %	>0.6 %
4	Pearl Millet	Iron	45.0-50.0 ppm	>70.0 ppm
		Zinc	30.0-35.0 ppm	>40.0 ppm
5	Finger Millet	Iron	25.0 ppm	>38.0 ppm
		Zinc	16.0 ppm	>24.0 ppm
		Calcium	200.0 mg/100g	>400.0 mg/100g
6	Small Millet	Iron	25 ppm	>55 ppm
		Zinc	20 ppm	>33 ppm
7	Lentil	Iron	45.0-50.0 ppm	>62.0 ppm

- 88% of the countries experience at least two types of malnutrition.
- 29% of the countries possess three types of malnutrition.
- South Asian region is affected the most by malnutrition with 31.7% and 14.3% of the children (<5 years) being stunted and wasted, respectively.
- Malnutrition contributes to a loss of 11% of GDP in Asia and Africa.
- Malnutrition in all its forms could cost society up to US$3.5 trillion per year.

Status of malnutrition (Indian scenario): -

- 21.9% of the population lives in extreme poverty.
- 15.2% of people are undernourished.
- 38.4% of the children (<5 years) are stunted, 21.0% are wasted and 35.7% of the children are under-weight.
- Stunting varies greatly (12.4-65.1%) across districts, with 239 of 640 districts having stunting levels above 40%
- 58.4% of children (6-59 months), 53% of adult women, and 22.7% of adult men are affected due to anemia.
- 70% of children (<5 years) are estimated to be iron deficient.
- 38% of children (<5 years) are estimated to be deficient in zinc.
- India loses over US$12 billion in GDP per year to vitamin and mineral deficiencies.

Source: 2016 Global Food Policy Report.

Conclusions

To sum up, Fe and Zn enrichment of grains in many crops has already been achieved. Novel biofortification programs and strategies need to be developed to tackle micronutrient insufficiency in crops, particularly considering new environmental constraints. Microbe-mediated biofortification has great potential and warrants further research. New technologies should aim to enhance genotypes that could be used in biofortification programs and to additionally develop techniques for faster breeding, dissemination, and implementation of Fe and Zn-enhanced cultivars. Finally, the mineral nutritional quality of food crops should aim to encompass all major macro, micro, and antinutrients. There is a need to integrate more micronutrients and broaden biofortification projects beyond Zn and Fe. Additional regulations are needed to address public safety concerns, ensure adequate monitoring and implementation of transgenes in biofortified crops, and illuminate the effect of transgenic crops on human health. Biofortification efforts of major crop plants should be augmented to respond to new nutrition and health challenges related to the double burden of malnutrition and address the need for diverse and sustainable diets with a maximum beneficial impact around the world. Collaboration between different parties, plant breeders, farmers, consumers, scientists from various disciplines, and national and international organizations and governments is of crucial importance in this instance. Finally, biofortification strategies should be well incorporated into the nutritional agendas so that a vision of reaching 9 billion people by 2030 can turn into a reality.

Future Thrust

Biofortification of crops is a challenging endeavor. Many plant breeding programs focus on the improvement of productivity, resistance to biotic and abiotic stresses, and food palatability. The improvement of nutritional quality has been added as an additional breeding objective in recent years. To achieve these objectives, collaboration between plant breeders and nutrition scientists is essential. Moreover, it is not possible to implement some of the biofortification programs due to the lack of sufficient genetic variation for the micronutrients in the germplasm. In such situations, the application of genetic engineering approaches is needed and collaboration between plant breeders and molecular biologists is essential. The biggest hurdle in the commercial use of GM crops is the regulatory approval process which is very expensive and time-consuming. Biofortification is a promising agriculturally based strategy for improving the nutritional status of malnourished populations throughout the world. Therefore, major resources should be allocated to biofortification programs.

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