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Biofortification in Fruits and Vegetable crops

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Abstract:-

Biofortification is the process of increasing the nutrient content of crops through agronomic practices, conventional breeding, and modern biotechnology, enhancing their nutritional quality during growth. Unlike traditional fortification, which adds nutrients during food processing, biofortification makes the nutrients inherent in the plants. This method ensures consistent intake of essential nutrients, targets low-income households, and is cost-effective and sustainable. It also improves farm productivity, combats malnutrition, and enhances crop quality. Efforts in India and global initiatives like HarvestPlus highlight its significance. Examples of biofortified fruits and vegetables, such as bananas, oranges, apples, and carrots, demonstrate its potential to improve public health.

Introduction:

The term "biofortification" derives from the Greek word “bios,” meaning “life,” and the Latin word “fortificare” meaning “to make strong.”

Fortification: Fortification is the process of adding external nutrients, such as vitamins and minerals, to commonly consumed foods to increase their nutritional value. These nutrients are typically added in chemical forms during food processing. For example, adding iron to flour or vitamin D to milk.

Biofortification: Biofortification is a method of increasing the nutrient content of crops through agronomic practices, conventional plant breeding, or modern biotechnology.

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Unlike fortification, biofortification focuses on enhancing the nutritional quality of food crops as they are grown rather than during food processing. This process can involve increasing the levels of vitamins, minerals, and other beneficial compounds in the crops themselves.

How Biofortification Differs from Fortification: Biofortification differs from traditional fortification in that it aims to enhance the nutritional content of crops during their growth phase. This means that the nutrient enhancement is inherent in the plant itself, rather than being added externally during food processing. This approach makes plant foods naturally more nutritious.

Advantages of Biofortification:

1. **Regular Daily Intake:** Biofortified crops capitalize on the regular daily intake of food staples, ensuring that people receive essential nutrients consistently.
2. **Targets Low-Income Households:** Biofortification implicitly targets low-income households that may not have access to a diverse diet rich in essential nutrients.
3. **Cost-Effective:** After the initial investment to develop fortified seeds, recurrent costs are low. These seeds can be shared internationally, spreading the benefits of biofortification.
4. **Sustainability:** Once established, biofortified crop systems are highly sustainable. The nutrient-enhanced traits can be passed down through generations of crops.
5. **No Yield Penalty:** Biofortified seeds do not incur a yield penalty, meaning they produce the same or higher yields compared to non-biofortified seeds.
6. **Increased Farm Productivity:** Biofortified crops may help increase farm productivity by making plants more resistant to diseases and environmental stresses.
7. **Combat Malnutrition:** Biofortification is a strategy to overcome malnutrition by providing essential nutrients through daily diets.
8. **Nutritional Quality:** It improves the nutritional quality of daily diets, contributing to better overall health.
9. **Crop Quality and Germplasm Variability:** Biofortification enhances the quality of crops and increases the variability in germplasm, contributing to agricultural biodiversity and resilience

Global Impact on Biofortification

Historical Efforts in India: In the 1970s, Dr. Ramalingaswami of the Indian Council of Medical Research (ICMR) initiated a program that administered large doses of

vitamin A every six months to children. This program was instrumental in reducing the incidence of night blindness, showcasing an early effort to combat micronutrient deficiencies through supplementation.

HarvestPlus and Zinc Rice: HarvestPlus and its partners have been actively promoting the availability, adoption, and consumption of zinc-fortified rice across 58 districts in India. By 2018, their goal was to have 1.4 million farming households growing zinc-fortified rice. This initiative demonstrates a large-scale application of biofortification to improve public health.

International Conferences and Agreements: The Second International Conference on Nutrition (ICN2) held in Italy in 2014, under the theme "Better Nutrition Better Lives," highlighted the global awareness and importance of biofortification in improving nutritional outcomes.

United Nations Sustainable Development Goals (SDGs): The UN General Assembly adopted the 2030 Agenda for Sustainable Development in September 2015, which includes the following goals related to improving health and nutrition:

- **Goal 2:** End hunger
- **Goal 3:** Ensure good health and well-being
- **Goal 6:** Ensure availability and sustainable management of water and sanitation for all

These goals emphasize the importance of addressing malnutrition and improving health through various interventions, including biofortification.

Methods of Biofortification

1. **Agronomical Biofortification:** This method involves the application of fertilizers or soil amendments to increase the nutrient content of crops grown on mineral-deficient soils. For example, applying zinc fertilizers to increase the zinc content in rice or wheat.
2. **Conventional Breeding:** This approach uses traditional plant breeding techniques to enhance the nutritional content of crops. Examples include:
   - Increasing zinc levels in wheat, rice, and maize
   - Enhancing iron content in beans and pearl millet
   - Boosting pro-vitamin, A levels in sweet potato and maize
3. **Genetic Modification/Transgenics:** Genetic modification involves altering the genetic makeup of crops to increase their nutrient content. Examples include:
   - Increasing β-carotene content in rice (e.g., Golden Rice)
   - Reducing phytic acid levels in cereals to enhance mineral bioavailability

Utilization of Different Genes for Biofortification by Transgenic Means

Transgenic Approaches: Transgenic biofortification has the advantage of utilizing discovered genes across multiple crops. This method allows for the targeted improvement of nutritional content in a wide range of crops by incorporating specific beneficial genes.

Key Genes Used:

- **Phytoene Synthase:** Involved in the biosynthesis of carotenoids, including β-carotene. Utilized in crops like Golden Rice to enhance vitamin A content.
- **Carotene Desaturase:** Another enzyme in the carotenoid biosynthesis pathway, enhancing the production of pro-vitamin A compounds.
- **Nicotinamide Synthase:** Important for the biosynthesis of nicotinamide, a form of vitamin B3, which can be increased in various crops.
- **Ferritin:** A protein that stores iron, used in crops to increase iron content and improve iron bioavailability.

Examples of Biofortified Fruit Crops

Biofortification has been successfully applied to several fruit crops to enhance their nutritional content. Here are some examples:

1. **Banana (Iron and Provitamin A):** Scientists have developed biofortified bananas with higher levels of provitamin A and iron to combat deficiencies in regions where bananas are a staple food. The "Golden Banana" is an example that has been modified to contain higher levels of provitamin A.
2. **Orange (Vitamin C and Folate):** Biofortified orange varieties have been developed with increased levels of vitamin C and folate. These enhanced oranges aim to address deficiencies in these essential nutrients.

Examples of Biofortified Vegetable Crops

Crop	Variety	Richness
Carrot	Pusa Asita	Anthocyanin
Carrot	Pusa Rudhira	Lycopene
Carrot	Pusa Nayanjyoti	β- Carotene
Sweet Potato	Pusa Sunehri	β- Carotene
palak	Pusa Bharati	Vit-C and β
Brinjal	Pusa Safed Bainga KKM-1	White
Radish	Palam Hridaya	Anthocyanin
Tomato	Pusa Rohini	Lycopene
Amaranthus	Pusa Lal Chaulai	Anthocyanin
Beetroot	Detroit Dark Red	Anthocyanin
Broccoli	Palam Vichitra	**A**thocyanin

3. **Apple (Antioxidants and Vitamin C):** Efforts have been made to increase the antioxidant content, including phenolic compounds, and vitamin C levels in apples through biofortification. These biofortified apples offer enhanced health benefits compared to regular varieties.
4. **Papaya (Provitamin A):** Biofortified papayas with higher levels of provitamin A have been developed to help address vitamin A deficiencies. These papayas provide an additional source of this essential nutrient.
5. **Pineapple (Vitamin A and Vitamin C):** Biofortification efforts in pineapple have focused on increasing the levels of vitamin A (in the form of provitamin A carotenoids) and vitamin C to improve their nutritional value.

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