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Building Nutritious Food Baskets (BNFB)

Facts on Biofortification

What is Biofortification?

Biofortification is the process of increasing nutritional value of food crops by increasing the density of vitamins and minerals in a crop through either conventional plant breeding; agronomic practices or biotechnology.

Examples of these vitamins and minerals that can be increased through biofortification include provitamin A Carotenoids, zinc and iron.

How are crops Biofortified?

There are three ways to breed a biofortified crop

Conventional crop breeding techniques are used to identify varieties with particularly high concentration of desired nutrients. Two parents with desirable traits such as virus resistance, drought tolerance, or high yield from the target growing region to develop biofortified child varieties that have high levels of micronutrients (for example, vitamin A, iron or zinc), in addition to other traits desired by farmers and consumers. This is the most common approach in use in Africa and is the approach that has led to the successful Vitamin A rich orange-fleshed sweetpotato.

Agronomic biofortification entails application of minerals such as zinc or iron as foliar or soil applications, drawing on plant management, soil factors, and plant characteristics to get enhanced content of key micronutrients into the edible portion of the plant.

Biotechology is the process of inserting the specific genes responsible for a desired micronutrient from one variety into the DNA of another variety lacking any of the desired micronutrient.

Why biofortification?

Biofortification is one solution among many interventions that are needed to solve the complex problem of micronutrient malnutrition. Approaches range from the food-based approaches (such as dietary diversification, nutrition education and biofortification), to implementing food fortification and supplementation programs of essential nutrients such as vitamin A, iodine zinc, and iron; to inclusion of essential Nutrition Actions in national health and nutrition strategies, to incorporating infant and young child-feeding training into community health extension programs and water and sanitation programs.

Among these interventions biofortification is considered one of the most cost-effective interventions for countries to employ in combating micronutrient malnutrition[1].

Biofortification reaches rural consumers who have limited access to industrially fortified foods, supplementation interventions, and diverse diets. Most rural households already grow and consume staple food crops. Biofortification combines increased micronutrient content with preferred agronomic, quality, and market traits and therefore biofortified varieties will typically match or outperform the usual varieties that farmers grow and consume. Poor people often get 60-70% of their calories from staple food crops. Hence, biofortification targets the poorest consumers. In the long-term, dietary diversification is likely to ensure a balanced diet that includes the necessary micronutrients needed by rural poor populations.

What are micronutrients?

Micronutrients are a group of compounds that are needed in small amounts by human bodies for a wide range of essential functions and for proper growth and development (for example, vitamin A, iron, folate, or zinc). Healthy diets contain a balanced and adequate combination of macronutrients (carbohydrates, fats, and protein) and essential micronutrients.

What is micronutrient malnutrition or hidden hunger?

Micronutrient malnutrition or hidden hunger is caused by a chronic or prolonged lack of essential minerals and vitamins required for proper growth and development of the body. Micronutrient malnutrition is a major risk factor for increased incidence of

illness and low productivity and in young children, poor growth and even death. Deficiencies in different micronutrients have different effects (Table 1). The Factors that contribute to micronutrient malnutrition include poor diet, increased micronutrient needs during certain life stages, and health problems such as diseases, infections, and parasites. However, unlike wasting (severe underweight), symptoms of micronutrient malnutrition are not necessarily visible to the naked eye even when they are affecting health—hence, micronutrient malnutrition is referred to as the hidden hunger.

How does Biofortification differ from food fortification?

Biofortification has the increased nutritional micronutrient content bred into the crop being grown. Food fortification increases the nutritional value of foods by adding trace amounts of micronutrients to foods during processing.

Is there scientific evidence that biofortified crops are effective?

Yes! Scientific evidence suggests that biofortification is an efficacious, cost-effective, and feasible means of alleviating micronutrient deficiency. A growing number of completed efficacy (biological impact under controlled conditions similar to clinical trials) and effectiveness (biological impact in real life)studies show that biofortification works. Effectiveness evidence is available for orange-fleshed sweetpotato (Low et al., 2007[2]; Hotz, Loechl, de Brauw, et al. 2012[3]; Hotz, Loechl, Lubowa, et al. 2012[4]).

Nutritional efficacy has been demonstrated for vitamin A crops (OFSP (van Jaarsveld et al. (2005[5]), maize (Gannon et al. 2014[6]), cassava (Talsma et al. 2014[7])) and iron crops (bean (J. Haas et al., n.d.[8]), pearl millet (Finkelstein et al. 2015[9]), rice (J. D. Haas et al. 2005[10])).

In Uganda for instance, it was demonstrated that biofortification was 'good value for money' (cost effective). In this case, using the orange-fleshed sweetpotato combined with nutrition education at the community level, biofortification cost US$15-$20 per Disability Adjusted Life Year (DALY) saved, which the World Bank considers a highly cost effective intervention (World Bank 1993[11]; HarvestPlus 2010[12]). An assessment of several crops to determine the consequences of vitamin A, iron, and zinc deficiencies on micronutrient malnutrition in two East African countries, one Central African, one West African, South Asia, Southeast Asia and Latin America provides evidence on the effectiveness of biofortification among young children and adults (including pregnant women). The analyses have shown that the percentage reduction in the burden of VAD ranges between 3% and 30% in the case of vitamin A cassava, between 1% and 32% in the case of vitamin A maize, and between 40%, and 67% in the case of vitamin A sweetpotato.

What are the benefits of consuming biofortified foods as compared to other non-biofortified foods?

Consuming biofortified staple foods results in higher intakes of targeted micronutrients, which depending on the health status of the individual, can result in improved micronutrient status, thus avoiding the negative effects described in Table 1. Biofortification does not treat acute deficiencies, but contributes to the prevention of micronutrient deficiencies, thereby promoting healthy growth and development.

Are biofortified crops developed through genetnic modification (GMO)?

All of the biofortified crops released in Africa to date have been developed using conventional plant breeding,

Table 1. Major micronutrient deficiencies and their effects

Micronutrient deficiency	Effects Include
Iodine	Brain damage in newborns, reduced mental capacity, goiter
Iron	Anemia, impaired motor and cognitive development, increased risk of maternal mortality, premature births, low birthweight, low energy
Vitamin A	Severe visual impairment, blindness, increase risk of severe illness and death from common infections such as diarrhea and measles in preschool age children; (in pregnant woman) night blindness, increase risk of death
Zinc	weakened immune sytem, more frequent infections, stunting

Sources: Allen (2001); Andersson, Karumbunathan, and Zimmermann (2012); de Benoist et al. (2008); Micronutrient Initiative (2009); Wessels and Brown (2012); and WHO (2009; 2014a) including vitamin A orange-fleshed sweet-potato, maize, and cassava, as well as iron beans. Conventional breeding methods exploit natural variations existing within the crops. Plant breeders identify parent varieties with high vitamin or mineral levels, and then cross (male and female) varieties over several generations to produce plants that have the desired nutrient and agronomic traits.

GMO technology is safe and can be used to biofortify crops which has been the case for biofortified Gold Rice, Super Sorghum and vitamin A Bananas. These GMO crops have not been commercially released yet.

Biofortified orange-fleshed sweetpotato, yellow cassava, orange maize and iron beans were bred using conventional breeding approaches.

Who is likely to benefit from consuming biofortified foods?

Consuming biofortified foods is most beneficial to groups that are vulnerable to micronutrient deficiencies (such as vitamin A, iron, or zinc), including children, pregnant and breastfeeding women, and those whose diets are limited by low income and/or lack of access to diverse, healthy foods. Children have higher micronutrient requirements than adults, and pregnant women and lactating women have much higher micronutrient needs than non-pregnant, non-lactating women.

Is biofortification a 'silver bullet' to improving micronutrient malnutrition?

Biofortification is not the si only solution to improving micronutrient intakes. However, it is a cost-effective, food-based approach to improve the nutritional value of foods that are often low or lacking altogether in micronutrients. It is particularly effective when combined with efforts to improve nutritional knowledge and dietary practice at the community level. It complements efforts to increase dietary diversity and other interventions that address micronutrient deficiencies, such as fortification and supplementation.

Why a 'food basket' approach to scaling-up Biofortificiation?

A 'food basket' approach supports dietary diversity by making available a variety of biofortified crops to address dietary deficiencies among vulnerable populations. Dietary diversity takes care of nutritional needs while at the same time takes care of various consumer demand/tastes. For instance, in Nigeria, communities in the northern part of the country use maize as the staple to make traditional meals like gari and fufu, whereas in southern Nigeria, the principal ingredient in gari is cassava. Some states in the center of the country consume sweetpotatoes in great quantities. If the production and consumption of all three biofortified vitamin A crops—yellow cassava, orange maize, and OFSP—are promoted, virtually all areas of the country would have access to a sustainable, frequently consumed source of vitamin A.

Why do we need Biofortification as an intervention for reducing hidden hunger in Tanzania and Nigeria?

The overlap of cropping patterns, consumption trends, and prevalence of micronutrient deficiencies determine target countries and focus crops. The biofortification priority index (BPI), which ranks countries globally based on their production and consumption of priority crops and the rate of micronutrient deficiency among the target population, is one tool that can be used to understand this overlap. The BPI identifies Tanzania and Nigeria as top priority countries for their target crops.

The Global Nutrition Report of 2014[13] highlights the magnitude of vitamin A and iron deficiency in Nigeria and Tanzania. These countries also produce and consume staple crops that can be biofortified for increased vitamin A and iron content. When the prevalence of VAD is at least 15%, it is considered a major public health problem. Therefore, Nigeria and Tanzania are appropriate intervention countries for BNFB.

Where and how can farmers access biofortified crops?

Biofortified seeds and propagation materials are made available through extension programmes, market mechanisms or by programmes targeting nutritionally vulnerable communities and smallholder farmers. To find the location of quality planting material with trained vine multipliers or national research programs, refer to the Sweetpotato Knowledge Portal (www.sweetpotatoknowledge.org)

Table 2. Status of micronutrient deficiency, prevalence of under-5 stunting in Nigeria and Tanzania[14]

Country	Micronutrient Status of the Population (%)		Prevalence of Under-5 Stunting (%)
	VAD in Preschool Age Children	Iron Deficiency (women of reproductive age with anemia)	
Nigeria	30	49	36
Tanzania	33	40	35

Compiled from: 2014 Nutrition Country Profiles (IFPRI)[12]

Does the nutritional value of biofortified foods change after processing or cooking?

The nutritional value of foods changes with processing and cooking, and vitamin A is particularly susceptible to degradation when exposed to air, light, and heat. However, breeding targets are set to take into account nutrient stability and retention in biofortified foods, based on typical processing, storage, and cooking practices. Nutrition research suggests that biofortified foods retain sufficient micronutrients to improve human health even after cooking. The only potential exception is for the production of a processed products like gari, where the vitamin A cassava is chopped into minute pieces and exposed to high heat during its preparation.

Can consumption of too much Vitamin A cause toxicity?

Vitamin A toxicity is rare, but real. It can occur after long periods of high exposure to vitamin A, especially in areas where vitamin A supplementation and food fortification programs co-exist. However, toxicity is not a major issue when using beta-carotene as a source of vitamin A (e.g., using plant food OFSP, vitamin A maize, or vitamin A cassava). The body can regulate how much vitamin A to make from beta-carotene based on its needs. If the vitamin A status is within the normal limits, the body will reduce the expression of enzymes involved in beta-carotene cleavage to vitamin A.

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