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Food fortification:

An effective and safe way to fight micronutrient malnutrition and its consequences

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Contents

Introduction

Food fortification is one of the most accepted, scientifically proven and cost-effective ways to tackle micronutrient deficiencies on a large scale. Despite the available evidence on food fortification, there remain questions, concerns and misunderstandings around its efficacy and associated risks.

This brochure seeks to provide guidance and answers by drawing on the latest evidence to explain why this form of nutritional intervention is generally safe and effective in improving micronutrient status across target populations.

Why fortify staple foods?

Vitamin and mineral deficiencies affect around 2 billion people worldwide and have been identified as a global health issue in many low- and middle-income countries. Micronutrients (often referred to as vitamins and minerals) are essential for the body to function. Deficiency of micronutrients can be linked to anemia, adverse birth outcomes, night blindness, increased risk of mortality in children and pregnant women, increased risk of osteoporosis in adults and rickets in children, reduced resistance to infectious diseases, fatigue, and impaired cognitive function [1].

These outcomes have far-reaching social and economic consequences, not only placing a massive burden on individuals and families, but also increasing pressure on core public services such as health, social care and education. Studies show that micronutrient deficiencies can contribute to a loss of up to 5% Gross Domestic Product (GDP) [2]. For example, iron deficiency can contribute to a loss of up to 2% GDP in the worst affected countries [3]. Therefore, addressing micronutrient deficiencies on a large scale represents a proven opportunity to build healthy societies and sustainably boost local economies.

The ideal solution to addressing micronutrient gaps is improving diets through dietary diversification. Yet, the high level of resources, the availability and the accessibility required to ensure diets are varied enough to meet the micronutrient needs, often prevent reaching this goal through this approach alone. In this situation, food fortification, micronutrient supplements and biofortification are widely recognized as highly effective and affordable complementary strategies [4]. Well-implemented food fortification programmes significantly impact the health and productivity of target groups for a comparatively low cost. Food fortification with micronutrients has been ranked among the top three strategies in terms of economic return on investment due to its high cost-benefit ratio, according to analysis carried out by a panel of global economic experts for the Copenhagen Consensus Center [5]. The well-respected think tank noted its "tremendously high benefits compared to costs."

By successfully addressing micronutrient deficiencies on a large scale with relatively limited budget, food fortification can help countries reach their nutrition goals, improve the nutritional and health status of populations, enable them to achieve their potential and support economic prosperity on a national level. In addition, fortified foods can support households in meeting nutrition needs by improving affordability of a nutritious diet [6].

What is staple food fortification and how does it work?

Fortification is defined by the World Health Organization (WHO) as:

> **The practice of deliberately increasing the content of essential micronutrients (i.e., vitamins and minerals) in a food, so as to improve the nutritional quality of the food supply and provide a public health benefit, with minimal risk to health [7].**

In terms of staple foods, fortification can occur either before harvesting, in a process known as biofortification, or after harvesting, otherwise known as post-harvest or staple food fortification. Both routes offer benefits and can complement each other. This brochure focuses on post-harvest fortification. Biofortification uses technology to breed staple crops with enriched levels of micronutrients and is mainly focused on zinc, iron and provitamin A carotenoids. Whereas post-harvest fortification is the process of adding micronutrients to a commonly consumed food through one or more of the following approaches [1]:

- **Large-scale fortification:** Targeted at the population as a whole involving the addition of micronutrients to foods commonly consumed by the general public - particularly those populations considered most at risk [1]. For example, rice, wheat and maize flour, vegetable oils, salt or condiments, and milk. Very often mandated and regulated by law.
- **Small-scale fortification:** a large proportion of consumers depend on small-scale milling for staple cereals. These consumers can be reached by fortifying for instance, wheat, maize, cassava, sorghum, and millet at small-scale millers.
- **Targeted fortification:** Aimed at specific sub-groups rather than the population as a whole. Examples of this approach include fortified cereals and biscuits for older infants and children, as well as so-called "home fortification" where micronutrient powders or small amounts of other micronutrient-dense commodities, such as small-quantity lipid-based nutrient supplements (SQ-LNS) are added to foods ready for consumption.
- **Market-driven and purpose-led fortification:** Voluntary action taken by manufacturers to add one or more micronutrients to foods to improve public health, at affordable costs.

Support for Large Scale Food Fortification

Large-scale food fortification has been proven to be a highly successful nutritional intervention strategy as evidenced by a substantial body of research. For example, a recent systematic review and meta-analysis found that iron-fortified foods can reduce the likelihood of developing anaemia by 34%, iodine-fortified salt can reduce the risks of goitre by 74%, and folic acid-fortified flour can reduce the risk for neural tube defects by 41% [8]. It is also estimated that large-scale food fortification with vitamin A could protect nearly 3 million children per year from deficiency [8].

As a result, this form of public health intervention has gained the support of numerous global organizations. The WHO, for example, sets out clear recommendations for the fortification of staple foods appropriate to the target population, such as rice, oil, salt, maize flour and corn meal, and wheat flour [9]. The WHO, the United Nations Children's Fund (UNICEF), the World Food Programme (WFP), the US Centers for Disease Control and Prevention (CDC), the Global Alliance for Improved Nutrition (GAIN), Nutrition International (NI), Food Fortification Initiative (FFI), Bill & Melinda Gates Foundation (BMGF), PATH (Program for Appropriate Technology in Health), Helen Keller International (HKI), United States Agency for International Development (USAID), and others are also endorsing fortification initiatives as a means to fight malnutrition, especially where a nutritious diet including a diversity of fresh foods is inaccessible for a large proportion of the population. In Africa, 26 countries have mandates to fortify wheat flour, in Latin America 35 countries have mandatory wheat or maize flour fortification and nine countries in Asia have either mandatory or voluntary fortification of rice or wheat flour in place.

The role of micronutrients in health

Micronutrients are essential to healthy development, disease prevention, and wellbeing. Micronutrients must be obtained from the food as they cannot be produced in the body. The exception is vitamin D that the human body produces naturally when the skin is exposed to sunlight. Though only small amounts of micronutrients are needed, consuming the recommended amount can be challenging. Micronutrient deficiencies can have devastating consequences. Globally, at least 1 in 2 children under 5 suffer from hidden hunger due to deficiencies in micronutrients. The role of a selection of essential micronutrients is outlined in Table 1.

Table 1: Selection of micronutrients and their benefits*

Iron	Iron is critical for motor and cognitive development. Children and pregnant women are especially vulnerable to the consequences of iron deficiency. Iron deficiency is a leading cause of anemia which is defined as low haemoglobin concentration. Anemia affects 43% of children younger than 5 years of age and 38% of pregnant women globally. Anemia during pregnancy increases the risk of death for the mother and low birth weight for the infant. Fortifying flour with multiple micronutrients including iron is globally recognized as an effective, cost-effective intervention and was shown to reduce the risk for anemia by 32% [10].
Vitamin A	Vitamin A supports healthy eyesight and immune system functions. Children with vitamin A deficiency face an increased risk of blindness and death from infections such as measles and diarrhea. Globally, vitamin A deficiency affects an estimated 190 million preschool-age children. Vitamin A deficiency increases the risk for night blindness and infectious diseases and severity of respiratory infections. Fortification with multiple micronutrients including vitamin A has been shown to reduce the risk for vitamin A deficiency by 58% [10].
Vitamin D	Vitamin D builds strong bones by helping the body absorb calcium. This helps protect older adults from osteoporosis. Vitamin D deficiency causes bone diseases, including rickets in children and osteomalacia in adults. Vitamin D helps the immune system resist infections from bacteria and viruses. Vitamin D deficiency is associated with increased risk and greater severity of infection, particularly of the respiratory tract. Vitamin D is required for muscle and nerve functions. Available data suggest that vitamin D deficiency may be widespread globally. The human body naturally produces vitamin D when exposed to sunlight, but this varies based on geography, skin color, air pollution, and other factors. Also, sunlight exposure needs to be limited to avoid risk of skin cancer.
Iodine	Iodine is required during pregnancy and infancy for the infant's healthy growth and cognitive development. Globally, an estimated nearly 2 billion people have insufficient iodine intake [11]. Iodine content in most foods and beverages is low. Fortifying salt with iodine is a successful intervention – about 86% of households worldwide consume iodized salt. The amount of iodine added to salt can be adjusted so that people maintain adequate iodine intake even if they consume less salt.
Folate (vitamin B9)	Folate (vitamin B9) is essential in the earliest days of fetal growth for healthy development of the brain and spine. Ensuring sufficient levels of folate in women prior to conception can reduce neural tube defects (such as spina bifida and anencephaly). Folic acid is another form of vitamin B9. Providing folic acid supplements to women 15-49 years and fortifying foods such as wheat flour with folic acid reduces the incidence of neural tube defects and neonatal deaths.

Zinc	Zinc promotes immune functions and helps people resist infectious diseases including diarrhea, pneumonia and malaria. Zinc is also needed for healthy pregnancies. Globally, 17.3% of the population is at risk for zinc deficiency due to dietary inadequacy; up to 30% of people are at risk in some regions of the world. Zinc contributes to normal cognitive function. Fortification with multiple micronutrients including zinc has been shown to reduce the risk for zinc deficiency by 16% [10].
The B-vitamins	The B-vitamins are critical for supporting red blood cells and thereby, transporting oxygen throughout the body. While iron deficiency is regarded as the major cause of nutritional anaemia, vitamins B12, folic acid and riboflavin (vitamin B2), together with vitamin A, C and E have also been linked to anemia development and control [12]. B-vitamins play also a role in extracting energy from food and presenting it in a physiologically usable form. Through these functions, B-vitamins helps to reduce fatigue or low energy linked to inadequate status of B-vitamins. Thiamine (vitamin B1) deficiency causes beri-beri.

*Based on Micronutrient Facts website [13]

How to implement an effective and safe staple food fortification program

Food fortification programs should follow clearly defined steps in order to improve micronutrient status and achieve optimum health outcomes.

1. Select appropriate nutrients for fortification

While different vitamins and minerals are used to fortify staple foods, it is essential that each program is tailored for the target population; both in terms of fit with the dietary habits and addressing the co-occurring micronutrient deficiencies. Micronutrient deficiencies can be estimated 1) from consumption data providing an estimate of micronutrient availability or 2) from actual biological biomarkers for micronutrient status. Both approaches provide valuable data to define the most problematic micronutrients in population groups, though the latter approach is usually more expensive and more invasive than the former.

Household consumption and expenditure surveys

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