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Food based strategies to combat micronutrient malnutrition

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Abstract
Interest in micronutrient malnutrition has increased greatly over the last few years. In addition to the more obvious clinical manifestations, micronutrient malnutrition is responsible for a wide range of non-specific physiological impairments, leading to reduced resistance to infections, metabolic disorders, and delayed or impaired physical and psychomotor development. The World Health Organization (WHO) considers that more than 2 billion people worldwide suffer from vitamin and mineral deficiencies, primarily iodine, iron, vitamin A and zinc, with important health consequences (WHO, 2006). The present paper addresses the issue of combating malnutrition through food based approaches.

Keywords: food based strategies, fortification, dietary diversification, plant breeding, micronutrient malnutrition

Introduction
According to Food and Agricultural Organization (1996), Food-based strategies encompass a wide variety of interventions that aim at:
- Increasing the production of micronutrient-rich foods
- Increasing the intake of micronutrient-rich foods
- Increase the bioavailability of micronutrients

Food fortification, dietary diversification and plant breeding are approaches which are followed worldwide. These are discussed below.

Food Fortification
Fortification is defined by the *Codex Alimentarius* as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups. The fortification vehicle can be either a staple food, or a more-processed commercially-available food, and many have been tried (UNICEF, 2002) [4].

Table 1: Requirements of a Potential Fortificant

Commonly consumed by the target population
Constant consumption pattern with a low risk of excess consumption
Good stability during storage
Relatively low cost
Centrally processed with minimal stratification of the fortificant
No interactions between the fortificant and the carrier food
Contained in most meals, with the availability unrelated to socioeconomic status
Linked to energy intake

Source: (Food and Agriculture Organization, 1996) [3]

Food fortification is aimed to provide meaningful levels of the nutrient, usually 30% to 50% of the daily adult requirements, at normal levels of consumption of the food vehicle. The most successful global fortification experience is the fortification of salt with iodine. In many Asian countries, including Bangladesh, China, Indonesia and India, salt iodization is rapidly gaining ground. Once established in a country, salt iodization is a permanent and long-term solution to the problem of iodine deficiency. Fortified lozenges, containing a combination of vitamins and minerals: vitamin A, vitamin C, zinc, iron and folic acid, offer a new approach to providing micronutrients to beneficiaries who are children between 2 and 5 years, adolescent girls and pregnant and lactating mothers. In India lozenges are distributed to children and mothers on a daily basis along with the regular supplementary food provided through the Integrated Child Development Scheme.

Fortified complementary foods provided through public feeding programs and commercially marketed foods have also had a positive impact. In some state in India food provided to children and to mothers under the Integrated Child Development Scheme in cooked or ready-to-eat form is micronutrient enriched.

Table 2: Fortified Foods in developing countries

Country	Food Vehicles	Nutrients
Bolivia	Wheat Flour	Thiamine, riboflavin, niacin, folic acid, iron
Brazil	Dried Skimmed milk for complementary food programmes	Vitamin A and D
Chile	Wheat Flour Pasta	Thiamine, riboflavin, niacin, folic acid, iron Vitamin A and D
Columbia	Margarine Wheat Flour	Thiamine, riboflavin, niacin, folic acid, iron Vitamin A and D
Costa Rica	Margarine Wheat Flour Sugar	Vitamin A and D Thiamine, riboflavin, niacin, folic acid, iron Vitamin A
Dominican Republic	Wheat Flour	Thiamine, riboflavin, niacin, folic acid, iron
Eucador	Margarine Wheat Flour Sugar	Vitamin A and D Thiamine, riboflavin, niacin, folic acid, iron Vitamin A
Guatemala	Wheat Flour Pasta Skimmed Milk Margarine Sugar	Thiamine, riboflavin, niacin, folic acid, iron, calcium Thiamine, riboflavin, niacin, iron Vitamin A and D Vitamin A Vitamin A
Honduras	Wheat flour Milk Margarine Sugar	Thiamine, riboflavin, niacin, folic acid, iron Vitamin A and D Vitamin A Vitamin A
Mexico	Sterilized low fat milk, pasteurized low fat milk, evaporated whole and low fat milk, margarine and spreads	Vitamin A and D
Nicaragua	Wheat Flour Sugar	Thiamine, riboflavin, niacin, folic acid, iron Vitamin A
Panama	Wheat Flour Sugar	Thiamine, riboflavin, niacin, folic acid, iron Vitamin A
Paraguay	Wheat Flour	Thiamine, riboflavin, niacin, folic acid, iron
Peru	Wheat Flour Margarine	Iron Vitamin A and D
Venezuela	Wheat Flour Pre cooked maize flour Dried milk powder	Thiamine, riboflavin, niacin, iron Thiamine, riboflavin, niacin, vitamin A and iron Vitamin A and D
Nigeria	Enriched Flour	Thiamine, riboflavin, niacin, iron, calcium
South Africa	Enriched Maize Flour Margarine	Vitamin A and D Vitamin A
Zambia	Sugar	Vitamin A
India	Vanaspati, Margarine Salt	Vitamin A Iodine
Indonesia	Wheat Flour	Thiamine, riboflavin, iron, zinc
Malaysia	Evaporated milk, skimmed milk Table Margarine	Vitamin A and D Vitamin A
Pakistan	Oil and oil products	Vitamin A
Philippines	Filled Milk Margarine	Vitamin A and D Vitamin A and D, Thiamine
Thailand	Sweetened condensed milk	Vitamin A
Turkey	Table Margarine	Vitamin A and D

Source: Gillespie and Haddad, 2001 [8]

The definitions of fortification now includes: a single micronutrient added to food, multiple micronutrients added to foods (e.g. triple fortification of salt); supplements (e.g. 'sprinkles') added to weaning foods and porridges; foods bioengineered to contain micronutrients that are not present in the traditional varieties; vastly improved fortification techniques, allowing for multiple, stable and acceptable fortification. Successful fortification programs have been identified as needing at least the following: strong political commitment and the ability to enforce regulations in a facilitative manner; early private sector involvement and willingness to comply with regulations; public sector backing including endorsement by professional medical organizations and financial support by donors; strong and active consumer education to raise consumer awareness and promote demand (Gibson & Ferguson, 1998) [5].

Dietary Diversification – A complete approach

Dietary diversification/modification, involves changes in food production practices, food selection patterns, and traditional household methods for preparing and processing indigenous foods approach that aims to enhance the availability, access, and utilization of foods with a high content and bioavailability of micronutrients (Hagenimana, Oyunga, *et al.* 1999) [6].

Strategies to enhance the content and/or bioavailability of micronutrients in plant-based staples are the following-

1. Field fortification
2. Genetic engineering and plant breeding

Field fortification strategies can also be used to increase the content of certain trace elements (TE) in cereal grains by applying fertilizers to the soil to increase its content of selenium, iodine, and zinc, or to enhance their iron content (Welch, 2002) [7].

Plant Breeding

One sustainable agricultural approach to reducing micronutrient malnutrition among people at highest risk (i.e., resource-poor women, infants and children) globally is to enrich major staple food crops (e.g., rice, wheat, maize, beans and cassava) with micronutrients through plant-breeding strategies. These target groups are dependent on these staples for their sustenance. Available research has demonstrated that micronutrient enrichment traits are available within the genomes of these major staple food crops that could allow for substantial increases in the levels of Fe, Zn and provitamin A carotenoids (as well as other nutrients and health-promoting factors) without negatively impacting crop yield. Furthermore, Fe- and Zn-dense seeds can increase crop yields when sowed to soils deficient in these nutrients ensuring their adoption by farmers in these regions once they are developed. New varieties of rice, such as *Oryza sativa* contain beta-carotene and increased amount of iron {ferritin transgene} (Welch, 2002) [7]. The reduction of antinutrient substances that inhibit micronutrient bioavailability or the increase in substances that promote micronutrient bioavailability from staple plant foods are both options that could be pursued in breeding programs, although care needs to be taken not to compromise agronomic performance and sufficient attention paid to possible beneficial roles of compounds which reduce the bioavailability of trace minerals. Plant breeding is one technology that should be adopted by the world's agricultural community and that should be supported by the world's nutrition and health communities (Gillespie and Haddad, 2001) [8].

Conclusions

The World Health Organization (WHO) considers that more than 2 billion people worldwide suffer from vitamin and mineral deficiencies, primarily iodine, iron, vitamin A and zinc, with important health consequences (WHO, 2006). Malnutrition is both a cause and a consequence of poverty. Overcoming malnutrition is integral to liberating Asia's poor from a shortened life replete with illness, disability, and diminished capacity to learn and earn. Indeed human development, social equity, and poverty reduction in Asia and the Pacific cannot be achieved without improving nutrition (M.G. Venkatesh Mannar, 2006) [9]. Food fortification, dietary diversification and plant breeding are food based cost effective approaches, which can combat micronutrient malnutrition if mandatory steps are taken.

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