

Technical Brief

Zinc fortification

Why food fortification?

Food fortification is defined as the addition of nutrients to commonly eaten foods, beverages or condiments at levels higher than those originally found in food, with the goal of improving the quality of the overall diet. In industrialized countries, fortification has played a major role in increasing the dietary intake of those micronutrients for which deficiencies are common and of public health concern; the contribution of fortification programs to the virtual elimination of micronutrient deficiencies in these countries is widely acknowledged [1].

In lower income countries, fortification is increasingly recognized as an effective approach to improving the micronutrient status of the population. Relative to other approaches, fortification is thought to be the most cost-effective means of overcoming micronutrient malnutrition [2]. Programs are designed such that success does not require changes in the dietary habits of the population, thereby simplifying the implementation process. Nevertheless, public education is required to ensure the acceptance of the program and to encourage consumption of the fortified products. Fortification programs represent long-term strategies that may effectively prevent the development of nutrient deficiencies among recipients, although fortification alone may not be adequate to treat existing deficiencies.

Where the micronutrient deficiency is widely distributed in the population, national level mass fortification of centrally processed foods is an appropriate strategy. An example of a country with a nationwide zinc fortification program is Mexico, where zinc and other micronutrients are added to wheat and maize flours that are used in preparing bread and tortillas, the two principal staples in the country. In cases where large segments of the population at risk do not have ready access to centrally processed foods, fortification may also be implemented at the community level. With the latter strategy however, cost is higher, sustainability is uncertain, and quality assurance and control and governmental enforcement are more difficult to achieve. Targeted fortification programs can be developed to increase the intake of zinc or other nutrients by specific segments of the population who are at elevated risk of zinc deficiency, such as infants, young children, or pregnant and lactating women. In this case, special-purpose foods, such as infant cereals, other processed infant foods, or foods distributed in school lunch programs, can be fortified and distributed or made available in the regular marketplace. There are several examples of adding zinc to foods in targeted fortification programs [3].

Developing successful fortification programs

The government, the food industry and the research community all play key roles in developing successful fortification programs; cooperation among these three groups is extremely important for programmatic success and should be sought at an early stage of program development. A committee comprised of representatives of these groups should be created for planning, designing, promoting, regulating and supervising fortification programs. Examples of the roles played by each of the different participants in such programs are as follows:

- **Government:** initiates, coordinates, regulates, enforces and monitors programs;
- **Scientific community:** determines the prevalence of zinc deficiency, the sensory acceptability and efficacy of the chosen zinc compound and food products, and the overall effectiveness of the program;
- **Food industry:** helps define feasible, affordable fortification strategies, identify appropriate food vehicles and fortificants, develop quality assurance systems and implement educational campaigns to reach target populations.



Technical considerations for zinc fortification

Selection of appropriate food vehicles

For a food to be an acceptable vehicle for a fortification program, it should be consumed by a large portion of the target population in relatively constant amounts. This way, fortification will result in a predictable and fairly stable level of intake of the added nutrient. This implies a need for reviewing pre-existing dietary data or collecting such information from a representative sample of the population (see *IzinCG technical brief no. 3, 2007*). Information derived from dietary surveys can be used to identify appropriate food vehicles and the usual amounts of these foods consumed by different segments of the population or target groups. The food to be fortified should be able to be processed in units large enough to permit controlled fortification. The fortified food should not have any objectionable changes in taste, color or appearance, and should retain appropriate levels of the added nutrients after further processing or cooking. Finally, the food should not be consumed in amounts large enough to present a risk of excessive levels of intake of the fortificant by any segment of the population [1]. Food vehicles that are candidates for mass fortification include staples, such as wheat or maize, and condiments, like salt, that are consumed by a large proportion of the population and that frequently are produced by just a few centralized factories.

Selection of the zinc fortificant

There are several zinc compounds that are available for fortification [4]. Though many compounds are listed by the USDA as generally recognized as safe (GRAS), there is no consensus as to which of the GRAS compounds is most appropriate for fortification programs. Zinc sulfate and zinc oxide are the GRAS salts that are least expensive and most commonly used by the food industry. Despite theoretical considerations that suggest that zinc may be better absorbed from water soluble compounds, like zinc sulfate, several studies indicate that zinc is equally well absorbed from cereal products fortified with either zinc sulfate or zinc oxide [5].

Determining the level of zinc fortificant

The proper level of zinc for mass fortification programs is that which would increase the intake of zinc by the targeted individuals, without imposing a risk of excessive intake on the rest of the population (IzinCG recommends a total zinc intake of no more than 40 mg per day by adults [4]). To determine the appropriate level of fortification, it is necessary to measure or estimate the amount of the food vehicle being consumed by different segments of the population. Participants in a conference on zinc in human health concluded that the appropriate levels of zinc fortification of cereal staples used for mass fortification programs is generally between 30 and 70 mg zinc per kg of flour depending on the range of usual flour consumption [6]. Higher levels may be desirable for foods targeted to young children. Other interventions, such as zinc supplementation, should be considered for completing the dietary/nutritional gap of those individuals with low consumption of the fortified food and/or larger nutritional needs.



Consumer acceptability of the zinc-fortified foods

Sensory trials are necessary to determine whether the chosen zinc compound and the level of fortification alter the consumer acceptance of the fortified product. For example, if fortification alters the taste, aroma, or cooking properties of foods, these foods may be rejected by targeted groups. Sensory trials can also be used to compare organoleptic qualities and consumer acceptance of products fortified with different forms of zinc and at different levels of zinc fortification. Available information indicates that the use of recommended amounts of zinc fortification does not adversely affect the sensory properties of the foods that have been tested.

Determining the absorption of zinc from fortified foods

Some potential food vehicles may have high amounts of inhibitors of zinc absorption, such as phytate, and the absorption of zinc fortificants varies when added to different foods. Since experience with zinc fortification is limited, it is worthwhile to conduct absorption studies; these studies should use appropriate zinc isotopic tracers to quantify the absorption of different fortificants used in candidate vehicles before final selections of fortificants and vehicles are made, unless relevant information is already available.

Food control

The quality of the fortified product also must be monitored on a regular basis, both at the level of the production site and at the point of purchase, to ensure that it contains an appropriate amount of the fortificant. Food control is carried out in two phases: quality control and assurance by the manufacturers, and enforcement in factories, importation sites and markets by the government. The latter set of activities includes auditing and inspection, which should be supported with analyses by reliable food control laboratories.

Monitoring and evaluation issues

Once the fortification program is in place, the effectiveness of the program to reduce zinc deficiency in the target group must be monitored and evaluated [7]. A system should be created to monitor changes in population zinc status periodically.

For more information on recommended indicators on population zinc status, see IzinCG technical briefs 1-3, 2007.

The cost of including zinc in ongoing fortification programs

Estimating costs is an important step in planning a food fortification program. Estimates must include both industry costs (e.g., capital investment and recurrent costs, such as the purchase of fortificant) and public sector costs (e.g., quality control, monitoring and evaluation).

Zinc fortification is unlikely to occur independently of other micronutrient fortification programs; thus the cost of a zinc fortification program can be calculated by assessing the additional costs of adding zinc to an ongoing fortification program. The cost of establishing a national wheat flour fortification program, for example, will vary according to factors such as the number and size of mills, existing quality assurance facilities, functional regulatory and food inspections, and the quantity of micronutrients being added [8]. The additional cost of including zinc in ongoing fortification programs will be the costs of adding zinc fortificant to the micronutrient premix, quality control in production, and monitoring and evaluation. The cost for a particular industry in a specific country should include the costs of the fortificant and any related international shipping, importation taxes, and transportation within the country. In mass fortification programs implemented by industry, 90% or more of the total cost of fortification is due to the price of the fortificants, which is relatively low for zinc compared with other micronutrients.

Although many of the quality control, monitoring and evaluation costs of adding zinc to an existing fortification program could already be covered by that ongoing program, some additional funds should be budgeted to cover the laboratory analyses associated with quality control and zinc determinations in plasma or serum specimen during program

monitoring and evaluation. Although food control activities under the responsibility of the national governments represent a low proportion of the overall program cost, it is important to provide adequate funding for this component of the program. Experience has shown that the lack of sufficient financing for such control activities is often a key factor in the failure of the food fortification programs in developing countries.

Scientific evidence of zinc fortification

The available studies clearly show that zinc fortification can increase total daily zinc absorption [5]. Thus, it is reasonable to conclude that individuals at risk of zinc deficiency who consume zinc fortified foods will have enhanced zinc status. Most absorption studies also show that adding zinc to food does not adversely affect the absorption of other minerals, like iron. Despite the known positive impact of zinc fortification on total zinc absorption, studies available to date in young children have not shown a positive effect of zinc fortified complementary foods on indicators of young children's zinc status, growth or other zinc-related functional responses, so additional research is needed. Among schoolchildren, however, two studies have found a positive impact on their serum zinc concentration [9,10].

In summary, zinc fortification appears to be a promising strategy to control zinc deficiency in terms of technical feasibility, cost, safety and impact on total zinc absorption, although there is currently limited empirical evidence of a positive effect of zinc fortification programs. Therefore, the nutritional and health impacts of zinc fortification programs should be rigorously evaluated.

This technical brief was prepared by Dr. Marie Ruel and reviewed by members of the IZiNCG Steering Committee.

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About IZiNCG

IZiNCG is the International Zinc Nutrition Consultative Group whose primary objectives are to promote and assist efforts to reduce global zinc deficiency through interpretation of nutrition science, dissemination of information, and provision of technical assistance to national governments and international agencies. IZiNCG focuses on identification, prevention and treatment of zinc deficiency in the most vulnerable populations of low-income countries. The Steering Committee of IZiNCG consists of 11 well-recognized international scientists with longstanding expertise in zinc nutrition and public health programs.

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