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Preventing zinc deficiency through diet diversification and modification

The ability to maintain adequate zinc status depends on the amount and bioavailability of zinc in the diet. In many developing countries, rural diets are based predominately on cereals or starchy roots and tubers. While animal-source foods are a rich source of bioavailable zinc, their consumption is often low because of economic, cultural, and religious constraints. Diets based on starchy roots and tubers typically have a low zinc content while those based on unrefined cereals and legumes contain high levels of phytate — a plant component that inhibits the body's absorption of zinc.

The diversification and modification of diets can enhance availability and utilization of foods with a high content of absorbable zinc (and other micronutrients) throughout the year. Several strategies exist to either increase the total dietary zinc content or to alter the level of zinc absorption from household diets and thus improve zinc bioavailability, even in subsistence farming settings.

What are dietary diversification and modification strategies?

Strategies to diversify or modify the diet aim to change food selection patterns and traditional household methods for preparing and processing indigenous foods.

Four main dietary strategies can be used at the household level to enhance both the content and bioavailability of zinc (and other micronutrients) in predominately plant-based diets. The choice of strategy depends on the population group, the setting, and the resources available. They may include the following:

1. Increasing the production and consumption of foods with a high content and bioavailability of zinc, like animal-source foods. Animal protein can also enhance the absorption of zinc (and non-heme iron).
2. Reducing the phytate content of cereal and legume-based staples to enhance zinc (and iron and calcium) absorption.
3. Increasing the intake of foods known to enhance zinc absorption.
4. Promoting exclusive breastfeeding from birth to 6 months of age, when safe and appropriate complementary feeding, including animal-source foods, should be added together with continued, frequent, on-demand breastfeeding.

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Increasing the production and consumption of foods high in zinc

This can be achieved by using the four approaches outlined below. Nutrition education and behavior-change interventions must also be used to ensure that each of the strategies is successfully promoted, implemented, and sustained. Selection of the most appropriate combination of strategies will depend on cultural, religious, socio-economic, and other factors in the population of interest.

- **Increasing production and consumption of small livestock**– such as poultry, guinea fowl, rabbits, guinea pigs, and small ruminants (i.e. goats or sheep). Efforts should be made to ensure that once produced, the livestock are not sold exclusively for cash, or consumed only on ceremonial occasions. Instead, appropriate livestock should be promoted for consumption by those household members at higher risk of inadequate zinc intake. Increased consumption of livestock will also simultaneously enhance intakes of protein, fat, heme iron, riboflavin, vitamin B_{12}, and, when liver is consumed, preformed vitamin A. Smaller increases in dietary zinc (and protein, fat, riboflavin, vitamin B_{12}, and calcium) can also be achieved by encouraging the consumption of dairy products and eggs.

Alternatively, processed snacks with ingredients such as dried fish, fish liver, or other organ meats, like kidney and heart, may be locally produced and marketed. For example in Thailand, beef or chicken livers are used to enrich a snack food prepared from a mixture of sago and tapioca flours [1].

- **Introducing aquaculture**–especially in countries where economic, religious, and/or cultural factors preclude the consumption of meat and poultry. Consumption of whole fish can increase the content of zinc in household diets as well as other limiting nutrients such as fat, heme iron, calcium (from bones), iodine, selenium, niacin, riboflavin, and preformed vitamin A when fish liver is included. Use of whole, dried small fish is especially desirable because it does not require refrigeration, and as a powder, can be used to enrich cereal-based porridges for infant and young child feeding [2].

- **Identifying indigenous zinc-rich foods** for consumption by those household members at high risk of inadequate zinc intake. Examples include consumption of sago grubs in Papua New Guinea.

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Household phytate-reducing strategies

• **Soaking** cereal and legume flours in water can reduce the phytate content of certain cereals, like maize and rice, and most legumes, such as mung beans or common red beans, because their phytate is stored in a relatively water-soluble form. Hence, phytate can be removed by simply soaking the flours in excess water and draining it off prior to cooking. A simple procedure that can be used by rural subsistence households is described below. This practice can reduce the phytate content of unrefined maize flour and mung bean flour by about 50% [3,4].

Instructions for soaking the maize

1. Pound maize
2. Mix one part pounded maize in four parts of water in a bucket
3. Soak for one hour
4. Decant excess water
5. Dry maize in sun and then mill.

• **Fermentation** can induce phytate hydrolysis and decrease its inhibitory effect on zinc absorption [5]. The extent of phytate reduction through fermentation of cereal-flour slurries or porridges varies, but reductions of about 50% can be achieved for some cereals [3]. However, in cereals with high tannin content, like bulrush millet and red sorghum, the tannins decrease the phytate-reducing effects of fermentation. Fermentation also improves protein quality and digestibility, vitamin B content, and microbiological safety and keeping quality.

• **Germination** (malting) can increase endogenous phytase activity in some cereals and legumes. Use of a mixture of cereal flours prepared from germinated and ungerminated cereals will promote some phytate hydrolysis, when the mixture is made into porridges for infant and young child feeding. An additional advantage of using such a mixture is that porridges can be prepared with a higher dry matter content, and still have a semi-liquid consistency suitable for infant and child feeding, without having to dilute them with water. As a result of this practice, the energy and micronutrient densities of these porridges will be higher and their phytate content lower [2]. Germinated cereal flour can also be added to a ready-prepared stiff porridge made from ungerminated cereal flour to reduce its thickness.

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Increasing the intake of foods known to enhance absorption of zinc

• **Including even a small amount of animal protein** from fish, poultry, guinea fowl, rabbit, goat, or eggs increases zinc (as well as non-heme iron) absorption. This enhancing effect has been linked with certain amino acid and cysteine-containing peptides released during the digestion of animal protein, forming soluble ligands with zinc [6].

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Breast feeding and complementary feeding practices

• **Exclusive breastfeeding** from birth to 6 months of age provides full-term normal birthweight infants with their nutrient needs for zinc [7], and also protects against gastrointestinal infections that can cause excessive zinc losses.

• **Safe and appropriate complementary foods** should be introduced at 6 months of age, with continued, frequent, on-demand breast feeding until at least 2 years of age as described in the WHO publication Guiding Principles for Improved Complementary Feeding Practices [7]. To ensure the nutrient needs for zinc are met, feed a variety of foods that includes meat, poultry, fish or eggs daily or as often as possible.

Strategy design and implementation

To ensure the sustainability of dietary diversification and modification strategies, there must be a systematic approach to making them culturally acceptable and economically feasible for the setting.

To implement these strategies effectively, the following types of information must be considered:

- Child feeding practices, dietary patterns and the availability and cost of foods
- Food beliefs, preferences, and taboos
- Nutrient and anti-nutrient contents of foods
- Cooking time and other workload of caregivers
- Nutrition education and social marketing strategies to foster behavior change.

A key element to ensuring this is the use of formative research—largely based on qualitative methods—undertaken within the target community. The recommended approach is outlined below:

- Use formative research to identify which strategies would be most appropriate for the cultural setting of interest;
- Conduct laboratory-based research to assess how

adoption of the proposed strategies would change the zinc and phytate content of the target group's diets;

- Test the proposed strategies in the field to find out which ones are most feasible and acceptable in the specific target group of the study community, also using formative research;
- Implement the chosen dietary strategies in the community by using:

  i. nutrition education;

  ii. behavior change interventions, such as social marketing.

The dietary diversification and modification strategies described here were used in two case studies in rural Malawi involving weanlings [8] and children aged 3 to 8 years of age [9]. Both case studies used a quasi-experimental design and implemented the strategies using formative research. The strategies resulted in diets that supplied significantly more animal-source foods, especially soft-boned fish, and less phytate. The result was higher intakes of absorbable zinc, as well as higher intakes of energy, protein, fat, calcium, and vitamin B_{12}. Furthermore, for the young children, the intervention appeared to have positive affects on the incidence of anemia, morbidity, and muscle mass [9].

Once the program is in place, the effectiveness of the program to reduce zinc deficiency in the target group must be monitored and evaluated. A system should be created to monitor changes in dietary zinc intake or population zinc status periodically. For more information on recommended indicators on population zinc status, see IZiNCG technical briefs 1-3, 2007.

Advantages of dietary diversification and modification strategies

Dietary diversification and modification strategies have several advantages:

- They can be designed to be culturally acceptable and thus more likely to be sustainable;
- They can be economically feasible, even in poor resource settings;
- They can alleviate co-existing micronutrient deficiencies in the entire household;
- There is limited risk of antagonistic interactions between nutrients;
- They are community-based and thus have the ability to empower the community to help themselves.

This technical brief was prepared by Dr. Rosalind S. Gibson and was 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.

IZiNCG secretariat

c/o Program in International and Community Nutrition
University of California
One Shields Avenue Davis, CA 95616, USA

Tel: +1 (530) 752 0814
Fax: +1 (530) 752 3406
E-mail: IZiNCG@ucdavis.edu
www.izincg.org

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