Micronutrients
and
health

Nutri*view* 2004/1

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Feature:

Controlling nutritional deficiencies in Egypt

In spite of efforts undertaken to improve nutritional status during the last decades, malnutrition is widespread in Egypt. The 2000 Egyptian Demographic and Health Statistics (EDHS) showed that, overall, 19% of children under five years of age are moderately stunted and 6% are severely stunted [1]. Levels are highest in the second year of life (under six months: 11%; 12 – 23 months: 24%; 4 – 5 years: 18%); they are slightly higher for males than for females and increase with birth order.

Children in rural areas are more likely to be stunted than urban children, as are children whose mothers never attended school (compared with those whose mothers completed the secondary level or higher). Wasting is found in nearly 3% of the children surveyed, while 4% are underweight for their age (children aged 6 – 11 months: 6.8%). Low weight-for-age is slightly more common among rural children, children in Upper Egypt, and children of mothers who never attended school. An earlier study [2] classified more than a third of the surveyed children as stunted. Rural areas had higher levels than urban areas (50.7% and 35.8% respectively). Prevalence was highest in Upper Egypt (60.4%).

Iron deficiency a major problem

The primary nutritional problem for Egyptian women is a tendency toward obesity. In the EDHS study, less than 1% had a BMI below 18.5, the level indicating chronic energy deficiency, while 77% had a BMI of 25.0 or higher.

According to the EDHS data, about 30% of Egyptian children and ever-married women aged 15 – 49 years are anemic. In most cases the anemia is mild; 11% of children under 5 years, 2% of older children and 5% of women have moderate anemia. Less than 1% suffer severe anemia.

Egypt has a salt iodination program and a vitamin A supplementation program. New mothers are given one vitamin A capsule (100000IU) within the first two months after delivery (reaches the infant through the breast milk). Infants are given one capsule at nine months (with the measles vaccination), and two capsules at 18 months (with the activated polio dose).

Diets lack vital nutrients

Exclusive breastfeeding is common but not universal in very early infancy in Egypt (79% during the first 2 months, falling to 34% at age 4 – 5 months). At age 12 – 13 months, more than 80% of infants are still being breastfed(2.5% exclusively). Most are weaned by the age of two years. The most common weaning foods are grain-based foods (porridge), followed by sweet potatoes and other tubers, fruit, fish, eggs and poultry.

In a cross-sectional study of representative sample households in rural and urban areas of nine governorates, Abdel Hameed et al [2] found a high prevalence of low nutrient intakes (<50% of the 1989 US RDA) for women(Table 1) and 2 – 6 year old children (Table 2). These data (especially for Fe and Zn) do not justify the whole problem of severe iron and zinc deficiencies, however. High prevalence of inhibitors and low prevalence of enhancers in the Egyptian diet can be the major contributors to the problem.

Choice of strategy

Several strategies (deworming, supplementation, food fortification, nutrition education, food-based approaches) have been proposed to control iron deficiency in Egypt, but none have been implemented as a national program.

Iron supplementation has been applied randomly for school children and pregnant women. It produced a significant impact during the program period, and should be recommended for all individuals suffering from iron deficiency anemia (IDA). Deworming and nutritional education have received little attention from the health authorities, so the impact has been negligible. Other approaches may be used prophylactically to prevent vulnerable groups from acquiring iron deficiency.

Fortification of an appropriate food vehicle is widely recognized as one of the most cost-effective and sustainable interventions for controlling IDA, and has been a clear success in many countries. Both staple foods and more processed commercial products can be fortified. To help control IDA, food fortification should therefore be considered in addition to iron supplementation of pregnant women and young children.

For a successful national fortification program, several conditions must be met:

- Public health significance of micronutrient deficiencies must be confirmed.
- Causes of inadequate micronutrient intake must be established.
- A staple food should be chosen that is consumed by all individuals.

Table 1: Percentage of women with intakes of selected nutrients below 50% of RDA. Abdel Hameed et al (2000)

	Nonpregnant/nonlactating		Pregnant		Lactating	
	Urban	Rural	Urban	Rural	Urban	Rural
Vitamin A	55.1	52.5	51.9	50.5	82.5	74.3
Vitamin C	41.6	35.9	51.9	45.2	63.1	47.4
Vitamin B6	14.8	21.3	38.5	48.4	28.2	42.6
Vitamin B12	21.9	55.5	21.2	55.9	26.2	60.9
Calcium	44.3	64.1	50.0	79.6	49.5	76.5
Iron	7.5	13.8	57.7	71.0	4.9	10.0
Zinc	8.6	20.6	19.2	36.6	32.0	52.6

Table 2: Percentage of children with intakes of selected nutrients below 50% of RDA

	Male		Female	
	Urban	Rural	Urban	Rural
Vitamin A	42.6	42.6	35.3	35.3
Vitamin C	45.4	39.8	30.3	37.1
Vitamin B6	2.8	2.5	1.7	1.7
Vitamin B12	6.4	21.1	3.4	20.3
Calcium	15.6	35.2	7.6	37.9
Iron	11.3	7.0	10.1	5.6
Zinc	4.3	5.6	5.0	3.9

- A fortificant should be chosen that gives the best bioavailability.
- A field study should be performed to confirm the efficacy of the fortificant and vehicle, and justify a national program.
- Quality control should be implemented to monitor the program and adapt it as needed.

Choice of vehicle

A major constraint to implementing an iron fortification program is that most diets in developing countries are characterized by a low content of iron absorption promoters (such as meat and ascorbic acid) and a high content of absorption inhibitors (in plant foods).

Because wheat is a dietary staple in Egypt, fortification of wheat bread is a logical intervention strategy in this country. The technology for fortifying flour is simple and relatively low-cost, making it a suitable vehicle for delivering iron and other micronutrients. Engaging the private sector in wheat flour fortification has been found to be less difficult than in the fortification of other vehicles. The very low per-unit cost of the fortificant premix (less than 0.5%) means that there is little, if any, need to increase the price of the finished product. Flour manufacturers are used to adding nutrients (to replace losses during milling), baking aids, whiteners, and other ingredients during the wheat milling process. Most machinery is already in place, and the quality control approaches are already known.

A major advantage of employing bread products as a vehicle for iron is the facilitating effect of wheat flour on iron absorption as compared with other cereal foods. Iron absorption from Western wheat-based meals in iron-deficient subjects varies between 20% and 30%, while only 2 – 4% of the iron in rice and maize meals is assimilated [3, 4, 5].

However, there is reason to suspect that Egyptian flat breads (baladi and shami) differ in their effect on iron availability compared with European bread. Baladi bread is made with locally produced 82% extraction flour, whereas shami bread is prepared with imported 72% extraction flour. Absorption studies in humans indicate that higher extraction flour substantially reduces the availability of added iron [6]. Furthermore, both types of Egyptian bread are baked at a higher temperature than European bread.

Studies [7] have shown that less iron is absorbed from Egyptian breads fortified with iron sulfate than from French bread (French bread: 13.5%; shami bread: 8.6%; baladi bread: 2.2%). The low absorption from baladi bread was almost certainly due to the higher content of bran; the higher baking temperature had only a marginal effect. Iron absorption from fortified baladi bread was the same whether it was eaten alone or with food, except when the meal included tea, which produced a threefold reduction in absorption (0.68%). Tea is the most potent inhibitor of nonheme iron absorption yet identified [8, 9]. As tea is almost always part of Egyptian meals, this may be a far greater impediment to an effective fortification program than the inhibiting effect of high extraction flour.

Choice of fortificant

Sodium iron EDTA (molar ratio of EDTA to iron 1:1) may be absorbed adequately even from meals with high inhibitor levels [10, 11]. However, increasing the molar ratio reduces iron absorption [12]. Use of an iron/EDTA fortificant is therefore potentially valuable, especially in diets that do not already contain appreciable quantities of EDTA.

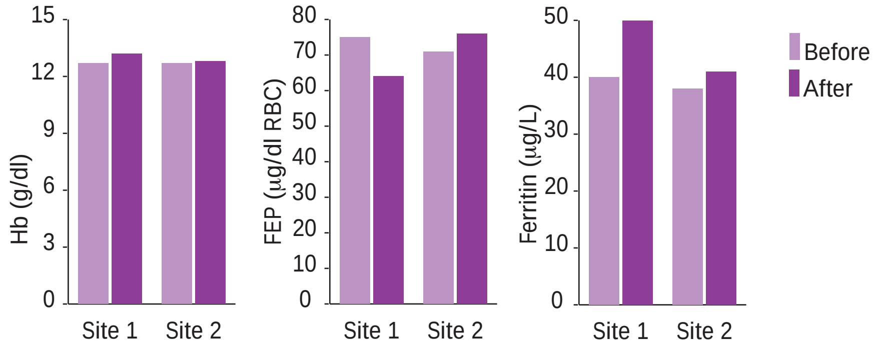
Sodium iron EDTA has been used to fortify a variety of vehicles including fish sauce in Thailand [10], sugar in Guatemala and masala seasoning in South Africa [11]. Iron absorption from meals containing baladi bread fortified with iron EDTA is nearly three times greater than that from bread fortified with iron sulfate alone [7]. Although EDTA is unstable at high temperatures, only a minimal reduction in absorption occurred when it was added before baking. Presumably exposure to these temperatures was too brief to have a major deleterious effect. The use of iron EDTA could offset the inhibitory effects of the typical Egyptian diet. However, further studies are needed to clarify the effects of EDTA and other enhancers and inhibitors on iron and other micronutrients.

Field study confirms efficacy

After establishing the potential value of iron EDTA to fortify baladi bread, we performed a field study in two Cairo orphanages [13]. Fortified baladi bread was served daily in one orphanage (Site 1), while unfortified baladi bread was served in the other (Site 2). Iron status parameters improved significantly in the children at Site 1 after one year (mean hemoglobin increased from 12.7 g/dl to 13.2 g/dl; free erythrocyte protoporphyrin (FEP) fell from 75 µg/100ml RBC to 64 µg/100ml RBC; serum ferritin rose from 40 µg/L to 50 µg/L), but there were no changes at Site 2 (Figure 1).

At the start of the trial, 18 children at Site 1 were below the cutoff level of hemoglobin, 8 were below the cutoff level of serum ferritin (<11 µg/L) and 21 children above the cutoff level of FEP (>80 µg/100 ml RBC). After one year, only 6 children were below the cutoff level of hemoglobin, 2 were below the cutoff level of serum ferritin, and 10 were above the cutoff level of FEP. In Site 2 changes in these indices were insignificant. Addition of iron did not affect the bread's organoleptic properties, and bread consumption increased at both sites.

Fig. 1: Iron status (mean hemoglobin / Hb; free erythrocyte protoporphyrin / FEP and serum ferritin) of children before and after eating iron-fortified bread (Site 1) or unfortified bread (Site 2) for one year [13].



These absorption studies have helped to implement the fortification program already launched in 2003 in the governorate of Fayoum. Further absorption studies will be required before extending this to a national program covering all governorates.

Additional measures

Dietary modifications may be necessary even after a food fortification program is implemented. Potential dietary modifications include increasing the intake of absorption enhancers (ascorbic acid, meat, poultry, fish) or reducing the intake of inhibitors (phytate, tannins, other polyphenols, calcium, tea, coffee). It is important to remember that these dietary factors affect the absorption of fortificant iron (unless an iron chelate such as EDTA, or hemoglobin is used) in the same way that they affect the absorption of intrinsic iron in the diet.

One way to improve iron absorption is to include an enhancing substance such as ascorbic acid (vitamin C) with the fortification iron [5, 14]. An increased vitamin C intake can also be ensured by eating fresh fruits and vegetables with meals [14, 15]. To determine if iron status of Egyptian school children could be improved by using such a simple food-based approach, we served a natural iron absorption enhancer (an orange) to a group of school children six days a week within the school lunch program [14]. The first phase of the project started in February 1999 and lasted for two months; the second phase began in February 2000. The duration of this phase was extended to three months to assess the effect of longer periods of intervention.

In the first phase, 300 children aged 10 – 12 years participated in the study. Half of them served as controls. In the second phase, 403 children of the same age range (from the same village but different schools) participated in the study and 82 children served as controls. The school meal provided to all children in both phases was biscuits fortified with iron. The children were tested for their hemoglobin levels and serum ferritin at the beginning and end of the designated intervention period. Stool analysis showed that half of the children were infected with at least one parasite.

During the first phase, the mean level of hemoglobin increased from 12.1 g/dl to 12.33 g/dl, while mean serum ferritin increased from 26.2 µg/L to 27.6 µg/L. In the second phase, mean hemoglobin increased from 11.82+1.29 g/dl to 12.43+1.04 g/dl in cases, and fell from 11.71 g/dl to 11.67 g/dl in controls. The same trend was seen in serum ferritin levels. Before treatment, 35% of the cases had a hemoglobin level <12 g/dl, while only19% did afterwards. Hemoglobin levels were higher in children with no parasites. The result of this intervention shows that a food-based approach (adding oranges to meals) can improve iron status significantly. Other approaches such as deworming and nutritional education should also be implemented.

Vitamin C in the meal enhances iron absorption!

Future steps

Further studies are needed before we can formulate a comprehensive national strategy to combat micronutrient deficiencies. These include:

- Absorption studies with different kinds of iron fortificant to help choose the best one for use with Egyptian 82% extraction flour.
- Studies to identify nutrient interactions affecting iron and zinc absorption in the (iron fortified) Egyptian diet in the target populations (especially healthy and diseased children).
- Studies on effects of dietary modification (increased intakes of iron-absorption enhancers and reduced intakes of inhibitors) on micronutrient status (I, Fe, Zn, vitamin A).

It is also important to consider inclusion of other nutrients in the fortification process to obtain the optimal benefit from the chosen strategy.

It is likely that several measures will be needed to overcome the problem of anemia and iron deficiency in Egypt. A future strategy will probably include iron supplementation, food-based approaches, nutritional education and deworming as well as food fortification. – *Mohamed A. El Guindi, Professor of Pediatrics, Consultant Nutrition, Gastroenterology and Hepatology, Menoufiya University, Egypt*

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Conference report:
Optimizing flour fortification in the Americas

On October 9 and 10, 2003, the Pan American Health Organization (PAHO) Regional Nutrition Unit jointly sponsored a regional meeting with the Centers for Disease Control and Prevention (CDC), the March of Dimes Birth Defects Foundation (MOD), and the United Nations Children's Fund, on flour fortification in the Americas. The aim of the meeting, hosted by the Institute of Nutrition and Food Technology (INTA) at the University of Chile in Santiago, was to translate current scientific and programmatic knowledge into practice, and so enable program implementers in the Americas to optimize flour fortification.

Representatives of the Ministry of Health, regulatory authorities and the flour industry from twenty countries (Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, USA, Uruguay, Venezuela) attended the meeting, as well as specialists from other organizations interested in flour fortification.

Lessons learned

Participants discussed how flour fortification has affected the prevalence of iron and folate deficiencies in the Americas, and reviewed the recommendations of the technical consultations on 'Iron Compounds for Food Fortification' (PAHO/ILSI/USAID/INACG) and 'Recommended Levels of Folic Acid and Vitamin B12 Fortification' (PAHO/MOD/CDC).

Experience from national flour fortification programs has been somewhat disappointing. Little success has been documented in efforts to reduce iron deficiency anemia. The reasons for this appear to be the type of iron used as a fortificant, the low iron dosage, and irregular or lack of quality control, surveillance and enforcement.

Many participants expressed concern about the quality of premixes used, and called for a technical norm to be established that would ensure minimum standards are met.

Recommended measures

The participants identified several ways to optimize flour fortification in the Americas. They recommended that both folic acid and vitamin B12 should be included in every program. Food fortification is the safest and surest way to ensure adequate intakes of folic acid, which is essential for the prevention of neural tube defects as well as anemia. Vitamin B12 is equally important for anemia prevention. It also helps to lower blood homocysteine levels (a precautionary measure agains cardiovascular disease) and prevents neurological damage (a possible consequence of excessive folate intake with concomitant vitamin B12 deficiency).

PAHO committed itself to elaborate a technical norm for premixes, in order to guarantee their quality.

Conference report:
Home fortification improves weaning foods

The risk of becoming malnourished increases dramatically when weaning begins around the age of six months. At this time, most mothers introduce home-made complementary foods to their infant's diet. Although filling, these foods usually do not contain enough micronutrients to satisfy the child's needs. Assuming that poor families have only limited access to industrially processed weaning foods and micronutrient-rich foods from animal sources, other alternatives need to be found.

An interesting direction currently being followed by researchers is to develop new, inexpensive vehicles for micronutrients that mothers can add to the weaning food as a kind of 'home fortification'. On October 19–21, 2003, the Micronutrient Initiative convened a meeting of interested specialists to review progress made in this field, identify the technologies ready for implementation, and stimulate collaborative efforts to introduce effective programs.

Among the most promising solutions being tested are sprinkles, dispersible/crushable tablets and fortified spreads. Sprinkles is the name given to a blend of micronutrients in a tasteless, dry-powder form. They can be packed in sachets containing a single serving, so mothers can easily mix the correct amount with the infant's food just before feeding. Sprinkles can be produced in a variety of formulations with a relatively simple technology.

Crushable tablets (e.g. the Foodlet; see Nutriview 2003/1) are readily soluble in water or milk, and can be mixed with food or chewed directly. Production relies on well-established pharmaceutical technology. They have been widely tested, and shown to be effective.

Fortified spreads may contain proteins, carbohydrates and vegetable fat in a concentrated paste, as well as micronutrients. Developed to treat severely undernourished children, they are more like a complete food or snack than the other formulations, but can also be mixed with traditional complementary foods. Production is with a simple, low-cost technology.

To enable the widespread implementation of these technologies, trials are ongoing to confirm that they are not only affordable and effective, but also safe, easy to use and acceptable to the mothers and their offspring. Progress made so far is encouraging.

1. The Micronutrient Initiative. Complementary food supplements and home level fortification workshop. October 19–21, 2003, Ottawa, Canada.

Review:
Ensuring good-quality fortified foods: A practical guide

This practical guide is the result of several years' collaboration between the U.S. Agency for International Development (USAID) and the International Life Sciences Institute (ILSI) Research Foundation. Its purpose is to provide program managers with information they need to ensure a good quality of fortified food. It covers everything a novice to the field requires to establish and run a quality assurance (QA) program. The information is clearly structured, the technical terminology is explained in simple words, and the theory is backed up with useful, real-world examples and clear diagrams.

Chapter one covers definitions of QA and quality control, how to implement a QA policy, elements of a QA system for food fortification programs, understanding the production process, and the government's role. Chapter two describes how to plan a QA system, how to monitor the production process, issues to be considered, and costs of developing and implementing a QA system. Chapter three highlights QA in the handling of the premix, in the manufacturing process, and in the distribution of the fortified food. Below is a summary of the three chapters.

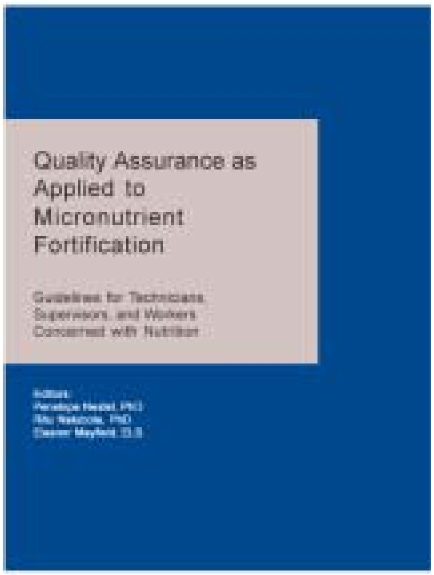
1. Definitions and elements of QA

Modern quality management has three interrelated elements: design, improvement, and control.

QA is a proactive, continuous system for monitoring reproducibility and reliability. Effective quality control and quality assurance systems are designed to allow quick, timely corrections to be carried out when deviations from quality standards are identified.

By developing a quality assurance policy and communicating it to all staff in the organization, management states its commitment to maintaining high quality in the food fortification process. Most QA problems result from faults in the physical system rather than from deficiencies in employee abilities.

Government agencies play a crucial role in assuring the quality and safety of a nation's food supply. Food laws and regulations and their enforcement are one way to monitor and ensure food quality.



2. Planning for QA

Planning a QA system applicable to fortified foods has two basic elements: establishing the technical and nutritional criteria and defining QA criteria for each component of the fortification process.

Monitoring is a systematic way to assure quality throughout the production process from handling of the ingredients to presentation of the fortified food to consumers. It is important to monitor where, when, and by how much manufacturing processes deviate from standards and specifications.

In setting up a QA system, it is important that management be fully committed to its implementation. The QA unit must report directly to management rather than to the production (or any other) department.

Developing and implementing a QA system incurs costs for manufacturers. However, having an effective system in place can reduce other costs.

3. Implementing a QA system

The first step in any QA system for food fortification is to confirm the quality, handling and storage of the fortificant or premix.

Most problems in food fortification relate to deviations from norms, resulting in quality standards not being met. For a food fortification program to be successful, the fortified food must reach the consumer in a condition that the consumer considers acceptable while complying with production standards and norms.

A copy of the book (PDF file) can be downloaded from: www.ilsi.org/publications/index.cfm?pubentityid=121.

– *A. Bowley*

1. Quality Assurance as Applied to Micronutrient Fortification. Guidelines for Technicians, Supervisors, and Workers Concerned with Nutrition. Eds: P Nestel, R Nalubola, E Mayfield. pp. 45. ILSI Press 2003.

Review:
Micronutrient deficiencies a "global disgrace"

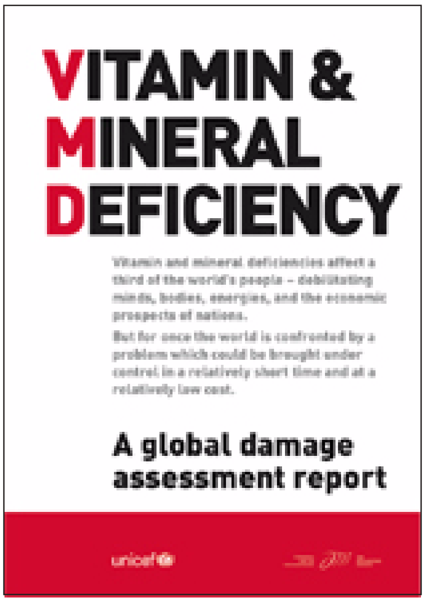
A new report from UNICEF and the Micronutrient Initiative [1] confirms that a lack of vitamins and minerals in the diet is not only damaging the health of a third of the world's people; it is also holding back the economic development of virtually every country in the southern hemisphere. Micronutrient deficiencies impair intellectual development and immune function, provoke birth defects, and condemn some two billion people to lives below their physical and mental potential.

The report summarizes the findings of nutrition 'damage assessment' studies in 80 nations that throw new light on vitamin and mineral deficiency levels that are almost impossible to detect without laboratory tests. The effects of these deficiencies on nations, and on their economic development, are only just beginning to be measured. “It is no longer just a question of treating severe deficiency in individuals”, warns UNICEF Executive Director Carol Bellamy. “It is a question of reaching out to whole populations to protect them against the devastating consequences of even moderate forms of vitamin and mineral deficiency. There is no excuse. We know what needs doing; we just have to do it”.

“The nutrition gap is one we can close immediately, simply and relatively cheaply”

The solutions are available

Whole populations can be protected against vitamin and mineral deficiencies by tested and inexpensive methods such as food fortification, supplementation, nutrition education and control of malaria, measles and intestinal parasites. Industrialized nations have been doing it for decades. However, micronutrient deficiencies cannot be brought under control in the developing world without a more ambitious, visionary, and systematic commitment to deploy known solutions on the same scale as the known problems.



According to Jay Naidoo, Chairman of the Board of the Development Bank of Southern Africa, and Chairman of the Global Alliance for Improved Nutrition (GAIN): “The nutrition gap is one we can close immediately, simply and relatively cheaply. For example, fortification of wheat flour in the 75 most needy countries could reduce iron deficiency by 10%, and birth defects by a third. It would cost about $85 million, which is about 4 cents per person. In return, these countries would stand to gain $275 million in increased productivity and $200 million from the enhanced earning potential”.

After a decade of dramatic developments, the facts are known, the solutions are available, and the cause is one in which governments, the medical and scientific community, civil society and private individuals must all become involved. “When so much could be achieved for so many, and for so little, it would be a matter of global disgrace if vitamin and mineral deficiency were not brought under control in the years immediately ahead”, the report concludes. ■

1. A copy of the report (PDF file)can be downloaded from the website of the World Economic Forum: www.weforum.org/pdf/initiatives/GHI_2004_UNICEF_MI.pdf

■ Events:

XXII IVACG Meeting, Lima, Peru, start date November 15, 2004

Theme: Vitamin A and the Common Agenda for Micronutrients (impacts of micronutrient interactions for populations at risk of VAD). It will be followed by the 2004 INACG Symposium.

Futher information: IVACG/INACG Secretariat, ILSI Research Foundation, One Thomas Circle, NW, Ninth Floor, Washington DC 20005-5802, USA; Tel: 202 659 9024; Fax: 202 659 3617; email: hni@ilsi.org ■

18th IUNS International Congress of Nutrition, Durban, South Africa, September 19 –23, 2005

Theme: Nutrition Safari for Innovative Solutions. Precongress Nutrition Safaris will be held at selected venues throughout Southern Africa on Sept. 17/18.

As well as creating a platform for dialogue on the newest developments in nutrition science (research, policy, practice) the congress will focus on innovative solutions for global nutrition problems and will aim to build capacity among ‘young’ nutrition scientists, public health nutritionists, clinical nutritionists, dietitians, food scientists, food service managers, etc.

Further information: Nutrition Safari, Private Bag X6001, Potchefstroom 2520, South Africa. Tel: (+27) 18 299 2469/4237; email: safari@puk.ac.za; website : www.puk.ac.za/iuns ■

B vitamins: further reading

For readers wanting more details about the B vitamins than shown in the Vignette on the next page, we draw your attention to the brochures published by the DSM Nutritional Products Task Force Against Hidden Hunger: ‘Food Fortification with B Vitamins’, and ‘The Role of Vitamins in the Prevention and Control of Anemia’.

The first describes the benefits of flour fortification, and shows examples of successful programs around the world; the second explains and documents the roles of vitamins in iron metabolism and hematological function. Both brochures can be found on the web site: http://www.roche-vitamins.com/home/what/what-hnh/what-hnh-mip.htm ■

B-vitamin deficiencies: a neglected health risk

For the past ten years, since the "World Declaration on Nutrition", considerable effort has been invested to eliminate deficiencies of iron, iodine and vitamin A. While the importance of these measures is undisputed, they may be falling short of optimizing people's health and productivity, because they usually ignore the role of the B vitamins.

B-vitamin status is critical

Thiamine (B1), riboflavin (B2), pyridoxine (B6), cobalamin (B12), folate, niacin, pantothenic acid and biotin play a key role in almost all body functions. They are essential for the proper growth and metabolism of cells, tissues and organs, and for the production and release of energy, hormones, antibodies and neurotransmitters. They might even help to prevent cardiovascular disease and cancer.

Most B vitamins are unstable, and significant losses occur during processing, storage and cooking of food. Liberation from food, and absorption into the body, is regulated by complex mechanisms (exceptions: B6, niacin), so that only a fraction of the amount ingested is normally assimilated (even less in people with intestinal disorders). Adequate dietary intakes must be frequent, because body stores are limited to only a few weeks (exception: B12). Requirements are increased during periods of rapid growth, pregnancy and lactation.

Measuring the risk

While the classical manifestations of B-vitamin deficiencies are rarely seen today, subclinical deficiencies are probably widespread[1]. Populations under distress conditions are particularly susceptible. Deficiency should be suspected in anyone presenting with symptoms such as poor appetite, lack of concentration, fatigue, irritability, dry skin, sore tongue, tingling sensations, muscle cramps or anemia. Population surveys should include data on B-vitamin status.

Reducing the risk

In industrialized countries, flour fortification has been instrumental in eliminating B-vitamin deficiencies. Countries contemplating staple food fortification programs could include B vitamins for little additional cost. ■

Further reading

1. Vitamin and mineral requirements in human nutrition: Report of a joint FAO/WHO consultation. Bangkok, 21–30 September 1998. <ftp://ftp.fao.org/es/esn/nutrition/vitrni/vitrni.html>

Table 1: Some facts about B vitamins

Vitamin	Health role	Best food sources	Factors increasing deficiency risk	Severe effects of deficiency
Thiamin	Growth, energy utilization, nerve function	Meat, poultry, legumes, whole-grain cereals	High intakes of tea, coffee, alcohol	Beri-beri, Wernicke-Korsakoff syndrome
Riboflavin	Growth; iron absorption and mobilization; activation of B6, folate, niacin	Milk, liver, eggs, legumes	Low intakes of dairy products; intestinal disorders	Anemia, vision loss, dermatitis
Pyridoxine	Growth, blood formation, nerve/immune function; activation of niacin, folate	Meat, fish, poultry, legumes, nuts, whole-grain cereals	Alcohol abuse; some medicines	Convulsions, anemia, dermatitis
Cobalamin	Growth, blood formation, nerve function, activation of folate	Meat, fish, poultry, eggs (foods contaminated with bacteria)	Vegan diet, lack of stomach acid and/or intrinsic factor; alcohol abuse; some medicines	Anemia, spinal cord damage
Folate	Growth, nerve function, bone marrow function,	Liver, green leafy vegetables, legumes	Malaria; intestinal disorders; some medicines	Anemia, congenital malformations
Niacin	Growth, energy utilization, hormone synthesis	Meat, poultry, legumes, nuts	Impaired tryptophan conversion; alcohol abuse	Pellagra (dementia, wasting, dermatitis, paralysis)
Pantothenic acid	Fat metabolism, nerve function, hormone and antibody synthesis	Meat, milk, eggs, legumes, vegetables, whole-grain cereals	Alcohol abuse	Numbness of hands and feet, low blood pressure
Biotin	Growth, energy utilization	Eggs, soya, nuts, whole-grain cereals	High intakes of raw egg white	Dermatitis, conjunctivitis, brain /spinal cord damage

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