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## Special Issue on Long-Term Food-Based Approaches Toward Eliminating Vitamin A Deficiency in Africa

*Food and Nutrition Bulletin*

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# Editors' preface

The June 2001 special issue of the *Food and Nutrition Bulletin* published articles on "Dietary Approaches to Vitamin A Deficiency" based on a workshop held in Seoul, Korea, immediately preceding the Eighth Asian Nutrition Congress on 27–28 August, along with some additional commissioned papers. The workshop was organized by the United Nations University (UNU) and the International Union of Nutritional Sciences (IUNS) out of concern for the sustainability of vitamin A capsule distribution, which has been the major international approach to the prevention of vitamin A deficiency in young children. This workshop and the resulting publication were judged to be exceedingly useful for the countries of the Asian region, but they did not include the rich experiences with plant sources of activity in Africa, and in particular with red palm oil on the continent on which the African palm originated.

This special issue is based on a similar workshop convened in Cape Town, South Africa, 22–23 November 2000, by UNU and IUNS with the participation of the Food and Agriculture Organization (FAO), the World Health Organization (WHO), and UNICEF and with support from the Micronutrient Initiative of Canada and the Malaysian Palm Oil Promotion Council. It seeks to capture some of the extensive experience with food sources of vitamin A activity in Africa, including the use of red palm oil as a rich source of provitamin A. To make the publication more complete, several additional papers were commissioned after the workshop. It is hoped that this publication will be a stimulus to greater focus on dietary approaches to the prevention of vitamin A deficiency in Africa, as has already been occurring in Asia. Consideration is being given to a similar workshop in Latin America.

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# Vitamin A deficiency control programs in Eastern and Southern Africa: A UNICEF perspective

Arjan de Wagt

## Abstract

*In several Eastern and Southern African countries, between one-third and one-half of the children are vitamin A deficient. Not just one strategy, but a combination of supplementation, fortification, and dietary diversification will provide the solution to the elimination of vitamin A deficiency. Food diversification in general is limited by increasing poverty and household food insecurity. Supplementation coverage rates increased from an average of 22% to 68% during the last four years. This was mainly due to integration of supplementation into national immunization days. Now the challenge is to integrate supplementation into sustainable delivery systems. Several countries have started or are planning maize and/or sugar fortification initiatives, but most of the experience so far has been on a pilot scale, and little is known about the impact of the interventions. There is a need to develop strategies for vitamin A supplementation and fortification of different foods to reach all areas and individuals in a country.*

## Introduction

At the World Summit for Children in 1990, the virtual elimination of vitamin A deficiency by the year 2000 was declared a global objective [1]. The International Conference on Nutrition in 1992 reconfirmed this goal [2]. Since these meetings, additional financial, human, and organizational resources have been made available to reach this goal.

In 1998, UNICEF, WHO, CIDA (Canadian International Development Agency), USAID, and the Micronutrient Initiative (MI) [3] launched the global vitamin A initiative. It was concluded that although progress had been achieved towards the goal of eliminating vitamin A deficiency, it needed to be accelerated. The initiative emphasized the need for realistic plans of action in combination with adequate funds. Vitamin A supplementation was considered a reliable and effective way to combat vitamin A deficiency that can be implemented rapidly on a national scale. Vitamin A fortification was put forward as a central strategy holding great promise for more extensive use in the near future, whereas horticultural programs might be useful in the longer term to complement supplementation and fortification programs [4].

Before the 1990s, the focus of UNICEF nutrition programs was more on the reduction of protein-energy malnutrition (PEM); however, since the World Summit for Children UNICEF has increased its support to projects for the reduction of micronutrient deficiencies, including the elimination of vitamin A deficiency. A UNICEF internal assessment carried out in 2000 showed that in many UNICEF country offices the financial support for nutrition improvement was proportionately larger for micronutrient interventions, especially for vitamin A and iodine, than for the reduction of PEM.

## Magnitude of the problem

Although reliable and recent data are not available for many countries in the region, it is clear from the available data that vitamin A deficiency is a serious health problem in Eastern and Southern Africa. The prevalence of vitamin A deficiency in the area is shown in table 1.

It is commonly believed that the major cause of the high rate of vitamin A deficiency is an inadequate diet. A large part of the population does not consume enough food to meet their calorie requirements, while the variety and nutritional quality of the food is often poor. Also, the high frequency of infectious diseases further increases the risk of vitamin A deficiency. The high prevalence of HIV/AIDS in the region can further worsen the situation through the following mechanisms:

- Increasing poverty and household food insecurity for families affected by HIV/AIDS;

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TABLE 1. Prevalence of vitamin A deficiency (<0.7 μmol/L) among young children in some representative countries of Eastern and Southern Africa

| Country | Year of study | Prevalence (%) |
|---|---|---|
| Botswana | 1994 | 32.5 |
| Ethiopia | 1996 | 38.9 |
| Kenya | 1994 | 33.8 |
| South Africa | 1994 | 30.0 |
| Zambia | 1997 | 66.0 |
| Zimbabwe | 1999 | >30.0[a] |

*a.* Preliminary data.

- Reduced child care capacity by parents infected with the virus;
- Inadequate care for the increasing number of orphans;
- Reduced food intake, reduced vitamin A absorption, and higher utilization of vitamin A by people living with HIV/AIDS.

## Vitamin A control programs

### Dietary diversification

Of the three strategies to combat vitamin A deficiency, dietary diversification seems to have received the least attention during the last 10 years. Interventions have been mainly on a relatively small, often pilot-project scale, and there is little known about the impact of the interventions. There are doubts about the contribution dietary diversification can make towards eliminating vitamin A deficiency in the region. Poverty levels and household food insecurity are very high, and, as said earlier, many people are not able to meet their calorie requirements. They do not have access to vitamin A–rich foods from animal sources and depend on dark-green leafy vegetables, fruits, and yellow or orange sweet potatoes for their vitamin A intake.

Other aspects that have further limited the success of the promotion of dietary diversification in the region include the following:

- The bioavailability of carotenoids from dark-green leafy vegetables, the major source of vitamin A for many people in the region, is low compared with that from supplements, and consequently a large amount of vegetables must be consumed to provide adequate levels of vitamin A.
- Consumption of fat or foods rich in fat is low, further reducing the bioavailability of carotenoids.
- Successful promotion of dietary diversification requires a behavioral change in food selection, food production and/or purchase, food preparation, and food consumption. So far, many interventions have focused on only one or a few of these aspects, without addressing the complete set of behavioral changes required.
- The promotion of complex and comprehensive behavior change requires more than simple messages (e.g., "Eat more vitamin A–rich food for health"). An information-education-communication (IEC) strategy needs to be combined with community mobilization, provision of (agricultural) inputs, and long-term promotion, support, and follow-up.
- Sustainable success of a dietary-diversification project is difficult to establish in a three- to five-year period, which is the lifespan of many internationally supported projects.
- Because of the different components of dietary diversification, an intersectoral approach is required. Intersectoral collaboration between sectorally organized government ministries and departments and even nongovernmental organizations and UN agencies presents many challenges.
- Major factors limiting large-scale interventions are the relatively large financial, human, and organizational resources required and the relatively long time required before the impact will be seen.

Success of supplementation interventions and high expectations about the impact of fortification initiatives reduce the interest in and resources available for the promotion of dietary diversification.

### Supplementation

Through the Vitamin A Global Initiative, more resources have been made available for countries to take action towards eliminating vitamin A deficiency in the form of donation in kind of commodities (vitamin A supplements), funds, technical assistance, and communication tools. Among the contributions, the donation in kind from the Micronutrient Initiative (MI) of 371 million vitamin A capsules in 1997–1998 and a cash contribution of US$1.1 million were invaluable, not only because the contribution was made prior to the official launch of the Initiative, thereby allowing rapid and significant results, but also because it was the first time such a comprehensive approach was taken to allow the implementation of large-scale programs in over 60 countries. The MI contribution has taken vitamin A supplementation programming to new global levels, probably saving hundreds of thousands of children and protecting the lives of millions of others. The contribution enabled countries to begin or expand nationwide programs and monitor their effectiveness. Logistical support has ensured efficient distribution of capsules and their availability when required.

An evaluation of eight studies of weekly or biannual vitamin A supplementation found decreases in preschool child mortality of up to 50% (Tamil Nadu, India) [5]. Extrapolating from the average of 23% reduction in mortality from this analysis, it is estimated that in 1998 one round of distribution of MI-donated vitamin A capsules averted up to 145,037 child deaths in Eastern and Southern Africa. These calculations were based on data from eight countries that reported high coverage rates (>70%) for one dose of vitamin A supplementation, but the actual duration of the effect on mortality from a single dose is unknown. Ethiopia also achieved high coverage rates with a second yearly round, further increasing the number of children's lives saved (table 2).

An increasing number of children in the region are infected through mother-to-child transmission of HIV. Several countries presently have infection rates of 15% to 30% among pregnant women, resulting in a possible prevalence rate among children of 5% to 10%. It is expected that vitamin A supplementation will do little for the survival of these children, and that most of them will die before they reach five years of age. Therefore, the above-mentioned figures on numbers of child lives saved might be an overestimate, but this will require further investigation.

By geographic region, the greatest number of countries adding vitamin A supplements to national immunization days (NIDs) was in 1998 in sub-Saharan Africa, where 18 countries included vitamin A with polio NIDs and another five countries combined vitamin A supplements with the measles campaigns. This represents an increase of almost 50% over 1997, when only 16 African countries added vitamin A supplementation to NIDs. The result is that vitamin A supplementation coverage rates for a single dose in sub-Saharan Africa have more than doubled in the last two years because of the opportunity to link with NIDs. Recent estimates by UNICEF show that in 1998, 68% of children under five years old in sub-Saharan Africa received at least one high-dose vitamin A through NIDs, special vitamin A campaigns, or other strategies.

» Challenges for the vitamin A supplementation projects are the following:
» Not all countries have yet started vitamin A supplementation;
» Through NIDs only one dose of vitamin A is delivered and not two annual doses as required;
» An increasing number of countries in the region do not plan NIDs in the coming years;
» Vitamin A supplementation is in many cases not an integral part of sustainable delivery systems; an expanded program of immunization (EPI) is recommended;
» In most countries vitamin A supplementation is funded mainly by donors, thus limiting its sustainability.

In the coming years, attention needs to be focused on sustainable integration of vitamin A supplementation into health service delivery projects, such as the EPI, integrated management of childhood illnesses (IMCI), health/nutrition/micronutrient days, growth-monitoring and promotion, and the Sustainable Outreach Services (SOS) package.

TABLE 2. Estimated number of lives saved and vitamin A coverage rates for countries reporting over 70% coverage

| Country | Coverage (%) | Coverage (thousands) | Lives saved (1 dose) |
|---|---|---|---|
| Eritrea | 86 | 477 | 4,153 |
| Ethiopia | 83 | 8,079 | 70,023 |
| Madagascar | 100 | 2,434 | 14,490 |
| Namibia | 83 | 195 | 368 |
| Rwanda | 75 | 780 | 7,581 |
| Somalia | 90 | 1,496 | 13,033 |
| Uganda | 95 | 3,604 | 27,601 |
| Zambia | 91 | 1,297 | 11,941 |
| Total | | 17,885 | 145,037 |

UNICEF believes that supplementation should include not just one micronutrient but, as much as possible, all micronutrients for which there might be a deficiency. Presently UNICEF is supporting pilot interventions on the distribution of a daily multimicronutrient supplement that includes vitamin A (one recommended daily allowance) to pregnant women in three countries in the region. This intervention is part of a larger maternal health and nutrition project. A safety study is also going on in South Africa on a multimicronutrient supplement for infants.

There is also an increasing interest in the development of a multimicronutrient supplement for people who have HIV/AIDS. The scientific information on the impact of multimicronutrient supplementation on the immune system, the viral load, occurrence and duration of opportunistic infections, disease progression, and the well-being of people living with HIV/AIDS is still relatively poor. However, the available information suggests that there is probably an impact of several of these indicators in countries where the diet is poor in micronutrients and micronutrient deficiencies are common.

### Fortification

Several countries in the region have started or are planning to fortify foods. Presently only sugar fortification in Zambia is at such a scale to be a major contribution to the vitamin A intake of the population. Fortification initiatives in the region are shown in table 3.

The list in table 3 is not complete, and there are several countries that are at different stages of planning fortification initiatives. Also, most of the supplementary food distributed as part of food aid in the region is now fortified with a mixture of micronutrients, including vitamin A.

As can be seen from table 3, Zambia, Zimbabwe,

TABLE 3. Fortification initiatives in Eastern and Southern Africa

| Country | Food fortified |
|---|---|
| Lesotho | Plans centrally produced maize flour fortification |
| Malawi | Some brands of maize flour, pilot on small-scale maize flour fortification, certain brands of cooking oil |
| South Africa | Planning maize and wheat flour fortification |
| Tanzania | Small-scale maize flour fortification |
| Zambia | Sugar, pilot on small-scale maize flour fortification, large-scale maize flour fortification planned |
| Zimbabwe | Some brands of maize flour, pilot on small-scale maize flour fortification |

Tanzania, and Malawi have small-scale maize-fortification initiatives. These projects aim to fortify maize flour with a multimicronutrient premix including vitamin A at village hammer mills. The project seeks to find an alternative for the fortification of centrally produced food, because the majority of the people in the region have limited access to such food. If this local fortification approach works, it will be an important strategy for reducing deficiencies of micronutrients, including vitamin A. However, the projects have to deal with several challenges, including quality assurance, community mobilization, mobilization and training of mill owners and operators, distribution of the premix, and sustainability.

If the small-scale fortification project cannot be taken to a nationwide intervention, there will be doubts that fortification will be the major contributor to combating micronutrient deficiencies in the region, and a continuing combination with supplementation will be required.

Fortifying foods with vitamin A faces the following challenges:

» There are only a few countries where centrally produced foods are consumed by a large part of the population. Local fortification is not yet proven to be an additional option.
» What strategies to adopt for the fortification of different products with vitamin A. Fortifying several products in order to have a wider coverage increases the risk that some people will have a relatively high intake of vitamin A.
» In several countries the government influences the production, distribution, import/export, price and sale of foods like staples, cooking oil, and sugar. A strong government influence can provide both opportunities and challenges for the fortification of foods.
» Experience with salt iodization has shown that regional harmonization of food-fortification legislation is an essential component for the success of fortification. Regional bodies like the Southern African Development Community (SADC) can assist with facilitating regional harmonization and therefore they should be involved at an early stage before national legislation on fortification has been established.
» Monitoring and law enforcement systems are relatively weak in most countries in the region. Therefore, it is important to have committed producers and this requires early mobilization and involvement of the private sector.

## Conclusions

Since 1990, interventions for the reduction of vitamin A deficiency have been developed in most countries in the region. Although at the beginning the focus was mainly on vitamin A supplementation, interest in food fortification is growing, and several new initiatives are expected in the next two years. Focus is expected to be on fortification of maize and sugar at the central level and further investigation of small-scale maize-fortification initiatives. It is hoped that with these new fortification initiatives together with improving and sustaining the coverage of supplementation and the implementation of large-scale dietary diversification projects, the goal of virtual elimination of vitamin A can be reached in the foreseeable future.

Some of the measures that need to be put in place to accelerate this continued fight against vitamin A deficiency include the following:

» Improved impact evaluation of the interventions. So far not many countries have instituted an adequate impact evaluation system. Challenges include limited capacity for doing nationwide impact evaluation and low prioritization of monitoring and evaluation in the allocation of both financial and human resources.
» Increasing and continued mobilization of communities, private sector, Government, and donors about the importance of vitamin A deficiency control and their roles in it.
» The development of strategies for the adequate combination of fortification and supplementation interventions without giving too much vitamin A to some and not reaching others.
» Research to further analyze the relationship between vitamin A status and HIV/AIDS-progression and transmission.
» Further development of multimicronutrient supplementation approaches for specific target groups.

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# Food sources of vitamin A and provitamin A specific to Africa: An FAO perspective

Georges Codjia

## Abstract

*Vitamin A deficiency is a major public health problem in Africa, especially in the Sahelian countries. It occurs mainly in young children and women of childbearing age. Inadequate intake of vitamin A is the main cause of the deficiency. The main animal sources of vitamin A are liver, eggs, milk, and milk products. They contain 25 to 8,235 retinol equivalents (RE)/100 g of edible portion. Even though these sources are rich in highly bioavailable vitamin A, their consumption among the population is still low. Plant foods rich in provitamin A represent more than 80% of the total food intake of vitamin A because of their low cost, high availability, and diversity. Fruits, roots, tubers, and leafy vegetables are the main providers of provitamin A carotenoids. Because of their availability and affordability, green leafy vegetables are consumed largely by the poor populations, but their provitamin A activity has been proven to be less than previously assumed. Among fruits, mangoes constitute an important seasonal source of vitamin A. Yellow or orange sweet potatoes are rich in provitamin A. Red palm oil has a high concentration of provitamin A carotenoids (500–700 ppm/100 g). Extension of new varieties with a high content of bioavailable provitamin A and locally adapted education and counseling on the handling and storage of provitamin A sources can significantly increase the vitamin A intake of vulnerable people. The Food and Agriculture Organization has implemented projects in several African countries to increase production and promote consumption of locally produced or available vitamin A–rich foods. The focus has been on women as the principal food producers and behavioral change agents. Adoption of food- and agriculture-based strategies as the best, appropriate, efficient, and long-term solution should be the focus of African efforts to improve nutrition. Food sources of vitamin A and provitamin A are plentiful in Africa. Food-consumption practices, food habits, and cultural aspects represent essential factors to be taken into account for successful implementation of these approaches.*

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## Introduction

Data on African foods with their vitamin A and provitamin A content, their consumption levels, advantages and limitations are presented in this paper. The major public health problem of vitamin A deficiency in Africa is caused by a dietary pattern providing too little bioavailable vitamin A to support physiological needs under the prevailing circumstances. In most of the sub-Sahelian countries, vitamin A deficiency is considered to be an important public health problem [1], both in terms of subclinical deficiency, with 18% to 20% of preschool children having serum retinol levels under 0.07 μmol/L, and in terms of clinical deficiency, with 0.24% to 1.06% of preschool children having clinical signs of vitamin A deficiency.*

As elsewhere, in addition to preschool children, women of childbearing age (mainly pregnant and lactating women) are at risk for vitamin A deficiency. The main reasons for their vulnerability to vitamin A deficiency are increased nutritional needs due to growth processes and an insufficient intake of vitamin A– and provitamin A–containing foods. Clinical and subclinical vitamin A deficiency and associated ocular morbidity, compromised immunological competence, and compromised tissue integrity contribute to an elevated mortality rate. Eliminating vitamin A deficiency can reduce mortality among preschool children by as much as 50% [2]. In Nepal, weekly supplementation of pregnant women with β-carotene or retinol at levels near those of the recommended dietary allowance was associated with a 40% decrease in the maternal death rate [3]. This shows how important vitamin A can be for good nutrition and health and suggests

* Arthur P. Oral presentation at the XVIII IVACG meeting in Cairo, Egypt, 22–26 September 1997.

that food sources of vitamin A may be especially important.

## Vitamin A food sources in Africa

Both animal and plant foods are sources of vitamin A activity provided in different chemical forms. Animal sources primarily contain preformed vitamin A (retinol and derivatives), whereas plant sources contain some carotenoids with provitamin A activity, such as α- and β-carotenes and β-crytoxanthin.

## Main sources of preformed vitamin A

Rich animal sources of vitamin A include liver, egg yolks, and whole milk and its products, such as butter and cheese. In Africa, fowl are common animal sources of preformed vitamin A, including chicken, guinea hen, and the less frequently consumed duck. Organ meats and flesh of goats, sheep, camels, and cows contribute preformed vitamin A to African diets.

Whole milk, its derivatives, and eggs have retinol contents ranging from 25 to 297 µg retinol equivalents (µg RE)/100 g of edible portion (table 1). On the other hand, liver (the reserve organ for vitamin A stored as retinyl esters) represents the richest food source of retinol from all animal species, containing from 810 µg RE/100 g of edible portion for cow liver to 8,235 µg RE/100 g for chicken liver [4]. Preformed vitamin A sources are highly bioavailable and rapidly absorbed from the digestive tract.

The intake of vitamin A from liver (goat and sheep) varies from 14% to 32% in Niger and South Africa [5, 6], and the contribution from eggs represents 2% of the vitamin A intake in Niger [5]. These consumption data, which indicate a low contribution of animal food sources to the total intake of vitamin A, are similar to those reported for Indonesian women, for whom animal sources represented only 11% of the dietary vitamin A intake [7]. Many reasons can explain low animal food intakes, including traditional food habits in Africa. The main limitation, however, is that animal sources of vitamin A are economically out of reach for most of the population. Even among livestock owners, meat consumption is low.

TABLE 1. Vitamin A content of the main animal vitamin A sources

| Food source | Vitamin A (µg RE/100 g edible portion) |
|---|---|
| Fresh whole milk (goat, cow, sheep, camel) | 25–95 |
| Eggs | 90.5 |
| Dairy butter (cow) | 130 |
| Cheese | 297 |
| Cow liver | 810 |
| Goat liver | 7,490 |
| Chicken liver | 8,235 |

Source: Ref. 4.

## Main sources of provitamin A

Food sources of provitamin A in Africa are numerous. Plant foods, such as dark-green leafy vegetables, orange and yellow sweet potatoes, carrots, squash, néré *(Parkia biglobosa*), and red palm oil, contain substantial provitamin A activity. Among fruits and vegetables, mangoes (*Mangifera indica*) were the most important source of vitamin A during the harvest season for 50% of young children in Niger [7].* Mangoes contribute 5% to 10% of the vitamin A intake during the harvest season; it decreases as the season ends. When available, mangoes can be eaten fresh or dried. Fresh mango pulp can contain 330 µg RE/100 g of edible portion and dried mango 477 µg RE/100 g [8]. The retinol equivalent of fresh mango pulp can vary, depending on the maturity of the fruit. A ripe mango can contain three times more micrograms of RE per 100 g than an unripe one [8]. The drying method can affect the final content of the provitamin A carotenoids in dried mango. Papayas *(Carica papaya*) can also be eaten dried or fresh. Fresh papayas contain 174 µg RE/100 g and dried papayas 64 µg/100 g [9]. In 1990–1992, the Food and Agriculture Organization (FAO) project "The Promotion of Production and Consumption of Vitamin A Rich Foods in Niger" developed solar ovens for drying mangoes and other fruits and vegetables.

The consumption of root vegetables, such as carrots (*Daucus carota*) and sweet potatoes (*Ipomoea batatas*), varies among African populations. Sweet potatoes represent only 8% of the provitamin A intake of children in Umlazi (South Africa) [6], whereas in Niger only 5% of the children eat carrots, the provitamin A content of which can vary from 475 to 3,262 µg RE/100 g, depending on whether they are dried, fresh, boiled, or fried.

Néré, the fruit of the African locust tree (*Parkia biglobosa*), containing 423 ± 109 µg RE/100 g, is one of the provitamin A food sources that are not consumed in large quantities [10]. It is widely used in the Sahelian region as a "condiment." Squash represents 5% of the total provitamin A intake in Niger, where it serves as a spice and contains 600 to 1400 µg RE/100 g.**

Interventions to reduce vitamin A deficiency have focused on the promotion of green leafy vegetables,

* Keith N. Preliminary report of data on small-scale research. Vitamin A social communication small scale project in Birni Konni. Helen Keller International, 1991.

** Helen Keller International. Projet survie de l'infant 2000. Niamey, Niger.

which often represent the main local source of vitamin A but have limitations due to bioavailability. In Niger, it was shown that the vitamin A activity of green leaves was less than supposed [10]. A study in Indonesia also clearly showed that the effectiveness dark-green leafy vegetables in improving vitamin A status was very limited [11]. It appeared that the bioavailability of carotenoids from green leafy plant foods depends on the food matrix in which carotenoids are contained; some food-processing methods, such as homogenization or processing, disrupt the matrix and enhance the absorbability and plasma response of β-carotene [9].

Another source of provitamin A carotenoids in Africa is red palm oil, an oil extracted from the pulp of the palm tree nut. It contains 500 to 700 ppm of provitamin A carotenoids [12–14]. Palm oil also contains vitamin E. Palm oil carotenoids are highly bioavailable, because there is no cellular matrix to inhibit absorption, and we know that intestinal absorption of carotenoids is better when some fat is present. The use of red palm oil could serve as a useful strategy in African countries to combat vitamin A deficiency. Many African countries, particularly in West Africa, already regularly use palm oil for cooking. Some education and counseling might be necessary to inform people how to extract, use, and consume red palm oil to ensure minimal loss of provitamin A activity.

## Importance of provitamin A sources in Africa

More than 80% of dietary intake of vitamin A in Africa comes from plant foods. The consumption of plant foods for their vitamin A activity has many advantages. They are accessible to low-income groups and are more adaptable to local food habits. Education and counseling on the use of plant foods can improve provitamin A intake among populations at risk of vitamin A deficiency.

The following are limiting aspects of vitamin A activity in plant foods:

- The provitamin A content depends on the variety of the plant in a producing region, even in the same country;
- The provitamin A content of fruits and vegetables depends on their maturity and seasonal availability;
- Due to the low bioavailability of carotenoids, large amounts of food are needed to satisfy vitamin A needs;
- Losses due to handling, cooking, and consumption patterns can decrease the amount of provitamin A.

There are two factors that can affect the measurement of vitamin A activity of plant foods. The provitamin A activity is calculated using food-composition tables, and it is known that they tend to overestimate provitamin A values obtained with plant foods. Updating and harmonizing food-composition table data by using techniques such as high-performance liquid chromatography (HPLC) can prevent overestimation of provitamin A intake from plant foods. Expressing provitamin A of plant food in retinol equivalents is questioned by many authors, because the validity of the bioconversion scale of provitamin A is uncertain.

## Contribution of FAO to the United Nations ten-year action program to control and prevent vitamin A deficiency (1985–1995)

After the 1992 International Conference on Nutrition, projects broader in scope on vitamin A were initiated and the FAO food-based approach program was consolidated. The FAO program involved increasing the production of appropriate vitamin A–rich foods and ensuring their distribution and availability to the populations throughout the year. This program was implemented in Africa, Asia, and the Pacific area. The program's global strategy emphasized an integrated approach, including horticultural activities, community participation, and involvement in key decisions, inter-sectoral participation, and women's participation to lead local interventions.

## Conclusions

There are many paths for Africa to explore to improve vitamin A and provitamin A intake among groups at risk for vitamin A deficiency. Technical aspects, such as processing, are important to improve the bioavailability and concentration of provitamin A carotenoids in common plant foods. Storage conditions and technical transformation of food sources should be studied further to make season-dependent provitamin A carotenoid food sources available in off seasons. The acceptability of effective foods, such as red palm oil, should be tested in nonconsuming populations, and carotenoid-rich wild plants should be indexed.

Reducing the financial limitations for the purchase of animal food sources of vitamin A would help. In addition to promoting income-generating activities, other global public health measures are needed to improve the access of vulnerable groups to vitamin A–rich food. Locally adapted community and school-based nutritional education and counseling programs to improve food practices are also important.

Appropriate strategies to prevent and control vitamin A deficiencies in Africa include dietary diversification, food fortification (with identification of locally consumed or accepted food vectors), breastfeeding promotion, public health measures, and vitamin A supplementation of vulnerable groups as an interim measure.

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# Planning a national food-based strategy for sustainable control of vitamin A deficiency in Ghana: Steps toward transition from supplementation

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## Abstract

*In an effort to control the high prevalence of vitamin A deficiency in Ghana, which studies have shown to be of public health significance, a number of interventions are being pursued. Periodic, massive-dose supplementation strategy, developed as a short-term life-saving intervention, is currently under way, either as part of the polio eradication program or combined with the existing health delivery system, schools, or community-based infrastructures. This has been successfully accomplished, and therefore the stage is set for the design and implementation of a long-term, sustainable solution. This is important in order to make the transition from a subsidized periodic capsule-distribution effort to a more sustainable food-based intervention, which could supply other vital nutrients as well as vitamin A in the diet. This report describes a proposal for a food-based strategy against a backdrop of low consumption in spite of the relatively high availability of some vitamin A–rich foods in most parts of Ghana. The aim is to improve vitamin A status of vulnerable groups through increased production, availability, and consumption of vitamin A–rich foods. The proposal is therefore to undertake a range of food-based interventions that will include horticultural interventions that aim to increase production and availability of vitamin A–rich foods, such as dark-green leafy vegetables and orange-colored fruits and vegetables and tubers in the diet of Ghanaian households. There will also be a comprehensive behavior change and communication strategy, to raise awareness of the causes and consequences of vitamin A deficiency and the need for consumption of adequate vitamin A–rich foods at the household level. Further emphasis will be placed on efforts to promote consumption of red palm oil, since this oil is generally available and not subjected to acute seasonal shortages. A phased community-based program will be implemented in four districts during the next three years, with the aim of applying lessons learned to the rest of the country. The monitoring framework will cover the planning process, provision of services, utilization of services, and coverage of target groups. These dietary approaches offer long-term sustainable options for improving the quality of family diets and overcoming vitamin A deficiency.*

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## Introduction

The Ghana Ministry of Health has identified vitamin A deficiency as a major public health problem that should be addressed in recognition of the adverse effects of vitamin A deficiency on the health and survival of at-risk groups. A number of data sources and studies have reported a high prevalence of vitamin A deficiency in the country, including the World Health Organization (WHO) updates on global prevalence of vitamin A, which indicate that Ghana has a severe deficiency problem [1]. The Ghana Vitamin A Supplementation Trial (Ghana VAST) studies conducted in the northern part of the country also provided prevalence data indicating that about 65% of children suffer severe vitamin A deficiency [2].

The 1997 Ministry of Health 1997 national vitamin A deficiency prevalence survey, which assessed the vitamin A situation in the southern sector of the country, reported that a high proportion of the children studied were vitamin A deficient. The prevalence survey conducted in all seven regions in the southern zone reported that although night-blindness was rarely seen, an average of 37.2% of the studied population had low serum levels of vitamin A, and the major determinants of the observed deficiency included low availability and inadequate consumption of the local vitamin A–rich foods.

## Progress made with vitamin A deficiency control programs

A national vitamin A deficiency control program framework outlined to address the high prevalence of vitamin A deficiency in the country proposed supplementation in the short term, food-based strategy as a long-term strategy, and use of vitamin A in the treatment of measles. These interventions have thus been designed and pursued as necessary to control the problem.

### Supplementation

A number of strategies are used currently in the periodic mass distribution of vitamin A. A six-monthly distribution is done with one round linked with the mass campaign administration of polio vaccine during National Immunization Days (NIDS). The second round of distribution uses community-based volunteers, health service contacts, or schools in the child-to-child approach. Although it has been successfully implemented, this periodic, massive-dose supplementation approach has been subsidized by external support and is therefore not sustainable in the long term.

### Food-based interventions

With the supplementation program under way, the groundwork has been established and the stage is now set for a food-based intervention, proposed in the national vitamin A deficiency control framework as the long-term option. It is crucial that a food-based option is put in place to make a gradual transition from supplementation to strategies that will address the underlying cause of inadequate intake of vitamin A.

The challenge facing the vitamin A deficiency control program, however, is that in spite of the relatively high availability of some vitamin A–rich foods in Ghana, their consumption has been low. The Ministry of Health prevalence survey revealed that only 19% of the population consumed dark-green leafy vegetables regularly. Despite its relatively wide availability, children rarely consumed red palm oil, and less than 40% of households consumed red palm oil in adequate quantities.

The Kintampo dietary trial, which studied the availability of local foods, acquisition, preparation, and food-consumption patterns of children, explored acceptability of the improved practices involving feeding meals improved with palm oil, and identified barriers to implementation of the strategy by mothers, provided insight into some of the potential food options. The results showed that a large variety of dark-green leafy vegetables were available to families and were mostly collected wild and preserved by direct sun-drying [3].

Barriers to adequate consumption were found to include cash, since it was the perception of respondents that vitamin A–rich sources, especially red palm oil, are expensive compared with household income levels which are low. Seasonal shortage in supply of vitamin A–rich foods, including mangoes, was also found to be an important contributory factor, because these foods are not preserved and traditional cooking methods were found to result in losses of vital nutrients [3].

## Proposal for food-based intervention

The availability of vitamin A–rich foods and the fact that these foods are appreciated and there are no cultural barriers to their consumption indicate that there may be a potential for dietary intervention for improving the vitamin A intake of vulnerable groups in these areas. These reports and other anecdotal data on diet culture and food-processing practices have indicated that fortification conditions do not exist, and therefore there is the need to look for an appropriate food vehicle, taking into account local and traditional dietary preference and processing practices.

The proposed long-term solution is dietary diversification, which will include horticultural interventions to increase the production and availability of vitamin A–rich foods, such as dark-green leafy vegetables and orange-colored fruits and vegetables. Horticultural interventions involving home gardening have been shown to be an effective approach to increasing production and consumption of foods rich in β-carotene [4–7]. Since they address the most important determinant of inadequate dietary intake, food-based approaches to improve vitamin A intake are the most rational, appropriate, and sustainable strategies to control vitamin A deficiency [6].

Another horticulture option proposed, in collaboration with the Ghana Crops Research Institute, is the evaluation and promotion of high-yielding varieties of sweet potatoes that mature within three to four months. This will entail the evaluation of orange- and yellow-fleshed sweet potato varieties locally available across the country and germplasm obtained from the International Potatoes Centre (CIP) in Kenya in farms in selected communities using the participatory approach. The preferred varieties will be promoted and some will be processed into gari to assess the acceptability of the different varieties to consumers. There will also be a promotion to increase use in areas where sweet potatoes are already consumed as snacks.

Further emphasis will be placed on efforts to promote the consumption of red palm oil, since it is generally available in Ghana; the Kintampo dietary study reported a high acceptability by consumers, and it is not subjected to acute seasonal shortages [3]. The oil palm is also the richest known dietary source of β-carotene with high bioavailability [8, 9], and it would provide an increased intake of dietary fat for the people in these target groups, who consume a low amount of fat. In addition, studies have shown that red palm oil is effective in increasing retinol levels in populations with marginal vitamin A deficiency [10]. The focus will be on management of proper distribution of available red palm oil from high-producing sites to other parts of the country and promotion of increased use and consumption. The effectiveness of adding palm oil to supplementary foods given to children aged six months to 5 years will be explored using the Trial of Improved Practices (TIPs) approach.

There is also a need for communication programs to improve practices related to consumption of the available vitamin A–rich foods. An intensive social-marketing strategy is particularly essential, since the current strategy for behavior change is limited to raising awareness of the benefits of vitamin A supplementation. Social marketing has been shown to be effective in promoting the consumption of carotene-rich foods and significantly reducing vitamin A deficiency [11]. Sustained improvements in the consumption of vitamin A–rich foods and fat have been demonstrated among targeted groups [12].

The social-marketing and behavioral change communication strategies include developing promotional messages in the mass media to create awareness of vitamin A deficiency and its consequences, the importance and benefits of vitamin A. The trained media practitioners who are currently part of the supplementation program will be involved in the behavioral change communication efforts. Health and agriculture extension workers at the district and subdistrict levels will be the front-line staff involved in interpersonal communication and provision of technical information on gardening and organization of demonstration classes.

Thus the program will undertake a range of dietary-based interventions that will promote carotene-rich food production and a comprehensive behavioral change and communication strategy, to raise awareness of the causes and consequences of vitamin A deficiency and the benefits of consuming adequate vitamin A–rich foods at the household level.

### Goals and aims

The proposed dietary intervention aims to improve the vitamin A status of vulnerable groups through increased production, availability, and consumption of vitamin A–rich foods.

### Objectives

» To improve household availability of vitamin A–rich foods through increased production by promoting community, home, and school vegetable gardens and planting fruit trees;
» To use the social-marketing approach to improve production, availability, and consumption of vitamin A–rich foods at the household level.

To achieve these two broad objectives, the following specific objectives will be pursued:

» To develop a social-marketing strategy to promote the production and consumption of vitamin A–rich foods;
» To improve the frequency of consumption of vitamin A–rich foods among children under five years of age;
» To improve awareness of the consequences of vitamin A deficiency and caregivers' knowledge of the benefits of consumption of vitamin A–rich foods;
» To develop a social-marketing strategy to promote the production and consumption of vitamin A–rich foods.
» To increase the consumption of red palm oil through the use of social-marketing;
» To develop, produce, and promote the consumption of suitable varieties of yellow-fleshed sweet potato.

### Methods and strategies

A community-based approach focusing on activities that will improve the production and consumption of foods rich in carotene at the household level will be implemented in four districts in four selected regions in Ghana during the first phase. Lessons learned during this phase will be used as a model that will be applied to other parts of the country.

The selection will take into consideration the geographic and ecological zones, urban-rural classification, and ethnic groupings. Community groups will be chosen in consultation with local politicians from the district assemblies and other local leaders.

Because community involvement and participation in the process are crucial to the long-term sustainability of the program, the implementation will entail community-based action programs, including consensus building and planning sessions, introduction of home gardens at the household level and school gardens, and planting of fruit trees by making seeds and seedlings available. Home gardening is not new in Ghana and is a traditional family food-production system widely practiced in many communities for growing vegetables and fruit trees. Studies have shown that home gardens in rural areas can increase both the production and the consumption of carotene-rich foods [6] and can increase micronutrient intakes [13].

Consensus-building meetings and consultative workshops will be held to bring implementers at all levels and collaborators together. These will culminate in a national consultative workshop that will discuss and finalize the strategy document as well as advocate for support. Advocacy and follow-up meetings will be organized at the district up to the community levels and with collaborating ministries, including ministries of Agriculture, Education, and Environment to solicit their cooperation and participation. A semiquantitative dietary survey and a knowledge, attitudes, and practices (KAP) survey will be undertaken to provide additional baseline data.

Preparatory activities will be undertaken, such as training in home gardening methods, demonstration classes, and provision of technical information in handouts and pamphlets, by a core group of trainers formed at the district and subdistrict levels to ensure successful gardening and achieving high yields. Issues on utilization that border on processing and preservation will be addressed during the initial training and in follow-up refresher sessions to address seasonal variability of the production and supply of fruits and vegetables.

Marketing techniques using the mass and print media and interpersonal behavioral change communication approaches to community groups will be implemented. A series of training workshops will be undertaken that will focus on imparting communication skills, project management skills, and technical gardening skills. Technical information on improved food production and preparation at the household level, community mobilization, and participatory skills will also be given. High-quality seeds and seedlings will be provided during the planting seasons to facilitate the start-up of gardens.

Community involvement and participation in the entire process will be encouraged to empower members and ensure community ownership and maintain continuity of the program. Partners at the community level will include women's groups, church groups, schoolchildren, and other functional groups.

To set the stage for the development of creative educational messages and social-marketing strategies, formative research will be carried out to study existing knowledge, attitudes, practices, and beliefs with regard to vitamin A deficiency. A number of advertising agencies will be contracted to develop, pretest, and launch communication materials.

#### Monitoring and evaluation

The implementation process will be monitored to assess progress and review strategies and logistics management throughout the lifespan of the project and at the end of the three-year period; impact evaluation will be undertaken using both qualitative and quantitative methods. The monitoring framework will cover the planning process, service provision, and use of services and coverage of target groups. There will be quarterly monitoring of the trained program staff and of the number of campaign materials produced and distributed, the number and frequency of campaigns, the trends in consumption of vitamin A–rich foods, the proportion of caregivers knowledgeable about vitamin A deficiency, the proportion of target group exposed to messages, and the proportion of target groups consuming vitamin A–rich foods. In addition, adequacy and timely supply of garden supplies such as seed and seedlings will be monitored.

Data-collection methods will include routine reports from the regions and districts, market survey training session evaluation, and quarterly supervisory visits to sites using checklists, KAP, and dietary intake surveys. Periodic household surveys will assess the impact of the intervention, focusing on behavioral indicators, increases in production, and changes in vitamin A status in the four pilot districts.

#### Program management

The Public Health Division of the Ministry of Health in collaboration with USAID, MOST (the USAID micronutrient program), and UNICEF will facilitate an intersectoral network to design and implement the intervention in four selected regions. The overall coordination and monitoring support will be provided by the Multisectoral National Technical Vitamin A Committee that has been formed with representation from the Ministry of Health, the Ministry of Agriculture (Crops Services), the Women in Agriculture Development (WIAD), the Crops Research Institute, and the Adventist Relief Agency.

The focal point of implementation will be the Nutrition Unit of the Ministry of Health, which will play a coordinating role. At the national level, the Head of the Nutrition Unit will be the program director and the micronutrient program coordinators will provide coordination support. The existing staff of the Ministry of Health, the Ministry of Agriculture, and the Crops Research Institute will provide coordinating, training, logistics management, and monitoring support at all levels of implementation. The multisectoral committee will also be formed at regional and district levels to oversee the implementation process.

## Conclusions

In Ghana, in spite of an existing successful supplementation program, the high dependence of this component on external support makes its sustainability questionable, and thus there is a need to explore other options. A shift of focus is essential to strategies that will address the low availability and inadequate intake of food sources of vitamin A activity. The added advantage of a food-based approach, which makes it imperative that efforts be made to implement these interventions, is that it is culturally more acceptable and appropriate and could provide other nutrients that are usually also deficient in the diet. Community involvement and participation in the process, including the training components and other inputs, will also empower communities to sustain the program. The program will promote the use of available sources of carotene, including fruits, vegetables, and red palm oil, which is abundant in the South, and explore the promotion of orange-fleshed sweet potatoes. In the long term, the national program must implement food-based options along the lines outlined above to complement and eventually replace vitamin A supplementation.

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# Experience of World Vision Ethiopia Micronutrient Program in promoting the production of vitamin A–rich foods

Haile Meskel Balcha

## Abstract

*Deficiencies of micronutrients are major health problems in Ethiopia. According to a national survey conducted by the former Ethiopian Nutrition Institute in 1985, the prevalence of Bitot's spots exceeded 1%, and low serum vitamin A levels were found in 16% of preschool children. In a 1997 baseline study by World Vision Ethiopia, the prevalence of Bitot's spots was 6.4% and 7.5% in preschoolchildren and schoolchildren, respectively. In October 1998, World Vision Ethiopia launched a comprehensive Micronutrient Program with the goal of improving the micronutrient and health status of mothers and children. Promoting the production of vitamin A–rich foods was adopted as one of the strategies to reduce vitamin A deficiency in the target population. Intensive nutritional education was given in the project areas, focusing on community leaders, women's groups, teachers, and students. Vegetable seeds and hand tools were made available for demonstration purposes, and production of vitamin A–rich foods (dark-green leafy vegetables, carrot, beet root, cabbage, and kale) was started in community demonstration plots and schools. Community members began replicating vegetable gardens at the household level. In areas where the climate is suitable, production of vitamin A–rich fruits, such as mango, papaya, and avocado, was also demonstrated to the communities. Seedlings grown in community plots were distributed to households. At the end of the second year (1999), 11,708 backyard gardens, 275 school gardens, and 77 community gardens had developed with the full participation of the community. In addition to improved micronutrient status, vegetable production contributed to household food security and income generation of the community. Our experience shows that production of vitamin A–rich vegetables is well accepted by the community. It is sustainable and cost-effective. The challenge ahead is the need to develop local vegetable seed production, since the availability and cost of imported seeds are a hindrance, particularly for very poor community members. A food-based approach, and particularly production of vitamin A–rich vegetables and fruits, should be the mainstay in designing a sustainable micronutrient program in poor developing countries.*

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## Micronutrient malnutrition in Ethiopia

Micronutrient malnutrition is one of the major public health problems in Ethiopia. This has been documented in several studies conducted in the country since 1958. In 1957–58, Postmus [1] clinically examined 7,000 preschool and school-aged children for xerophthalmia. He reported that 9% of the girls and 2.2% of the boys had Bitot's spots. In southern Ethiopia, Guseppe De Solo in 1987 [2] reported a 5% prevalence of Bitot's spots. In 1985, a national assessment of vitamin A status of children under six years of age was reported by the former Ethiopian Nutrition Institute. The survey included 42 semiurban survey sites, representing four ecological zones, which were identified based on the type of staple food crops [3]. The overall rate of Bitot's spots was 1%. According to this rate about 6 to 8 million Ethiopian children under six years of age were estimated to be at risk of vitamin A deficiency.

The prevalence of Bitot's spots was higher among children in pastoral areas (1.6%), followed by those living in grain-cropping (1.1%) and cash-cropping zones (0.4%). Overall serum retinol levels were deficient in 16% and low in 44% of the children. Most recently, a micronutrient baseline survey by World Vision Ethiopia [4] was conducted in 10 rural districts located in the northern, central, southern, and eastern regions of the country. The survey examined 1,246 children aged 6 to 71 months and 3,003 children aged 6 to 14 years for Bitot's spots.

The prevalence of Bitot's spots was 6.4% in children 6 to 71 months old and 7.5% in those 6 to 14 years old. Serum retinol levels were deficient in 8.3% and low in 46% of children 6 to 71 months old. These studies found a prevalence of Bitot's spots ranging from 2- to 15-fold of the World Health Organization (WHO) cutoff point (0.5%) for public health significance. Hence, micronutrient malnutrition, and vitamin A deficiency in particular, is one of the major public health problems in Ethiopia.

## Backyard gardens as a source of vitamin A–rich foods

Vitamin A–rich vegetables, such as dark-green leafy vegetables, carrots, and tomatoes, and vitamin A–rich fruits, such as mangoes and papayas, are alternative and reliable sources of vitamin A, particularly for poor rural communities that cannot afford animal foods. In addition, backyard gardens often improve household food security, since the produce adds to the quantity and variety of foods consumed by the household. Backyard gardens are also within the economic reach of the community members, since they require only a small piece of land and almost all members of the household can conveniently participate in the activity, usually in close proximity to their home.

## Production and consumption of vitamin A–rich foods in Ethiopia

Vitamin A–rich vegetables and fruits are traditionally grown in some parts of the country where water is available and the climate is suitable. However, the practice of consuming vegetables and fruits in rural communities is not well developed, mainly due to lack of awareness, and partly because of economic reasons, since some households produce them as a source of income. On the other hand, urban communities, which are relatively better educated and financially well off, purchase more vegetables and fruits. There are also some large-scale commercial farms that produce vegetables and fruits. Allthough their produce is mainly for export, a small part is consumed in large cities.

## The World Vision Ethiopia Micronutrient Program

The World Vision Ethiopia Micronutrient Program was launched in 1997 with the goal of improving the micronutrient and health status of the community, and of mothers and children in particular. The program is funded by the Canadian International Development Agency through World Vision Canada. The budget for the first phase (October 1997 to March 2001) was US$6.75 million. World Vision Ethiopia is implementing the program in collaboration with six partner nongovernmental organizations. The program supports 20 projects scattered in four major regions of the country, with about two million beneficiaries. The program uses a mix of strategies—supplementation, food-based approach (production and consumption of vegetables and fruits), and primary health care (prevention of communicable diseases causing or aggravating micronutrient deficiency). So far, food fortification has been limited to promoting the consumption of iodized salt. A feasibility study on village-level food fortification is planned during the second phase of the program. The first phase of the program was completed in March 2001, and it will be followed by a 12-month period during which consolidation of the first phase and preparation of project proposals for the second phase will be done.

## Program implementation

### Integrating micronutrient programs into ongoing development programs

The World Vision Ethiopia Micronutrient Program was designed to fit into ongoing development programs. World Vision Ethiopia delivers its development programs through Area Development Programs engaged in activities such as agriculture, health, education, and environmental protection. Since promotion of a nutritional program involves all of these activities, it was natural for the Micronutrient Program to fit into the ongoing development programs. The need for the integration was evident for two reasons. First, the ongoing programs provide skilled personnel in different disciplines, such as agriculture, health, and education, which are relevant to promoting nutrition programs. Second, integrating nutritional activities into ongoing development programs helps to ensure sustainability.

### Creating community awareness

Creating community awareness of micronutrient deficiency problems and how to avert them was crucial in stimulating community support for the program. Intensive nutritional education was given to the community at the project level utilizing all modes of communication, such as posters, leaflets, T-shirts, group instructions, and drama. Sensitization of community leaders, schoolteachers, and local development agents was also carried out, since they are usually the opinion leaders in the community.

### Training and technical assistance

Although the Micronutrient Program was integrated into ongoing development programs, it was still necessary to give the project staff orientation and short training on micronutrients. Technical assistance was provided by experts and professionals from the program coordinating office, under World Vision Ethiopia.

### Demonstration and replication of gardening at the household level

Community demonstration gardens were established jointly by the communities and the projects for teaching purposes. The communities provided land and labor, while vegetable seeds, hand tools, and technical assistance were provided by the projects. Growing plants for food is not a new idea for the rural communities. However, they lack the basic skills of modern agriculture and knowledge about consumption of micronutrient-rich vegetables and fruits. After acquiring the skills, the community members replicated the gardens in their backyards. Training on the preparation of vegetable food was also organized for the community members. Demonstrations of improved poultry raising were also begun on a small scale.

### Community participation

Since community participation is crucial for sustainability of the program, due attention was given to mobilizing and involving the community in the project activities from the very beginning. Community members allocated a piece of land for the garden. Schoolteachers and students participated in teaching the community by preparing songs and dramas. In some project areas, community gardens were managed by organized women's groups.

### Program monitoring

Each of the 20 micronutrient projects was visited regularly by program officers based at World Vision Ethiopia. The projects also submitted monthly and quarterly activity reports. There were regular quarterly review meetings in which project staff members discussed the implementation of the program and also shared experiences. The review meetings were organized by the project coordinating office based at World Vision Ethiopia.

### Program evaluation

#### *Baseline survey*

A baseline survey was conducted in 1997 to collect baseline data before initiating the micronutrient interventions against which to measure the impact of the program at the end of the project period. The survey was conducted in 10 project areas and involved 6,017 households from which socioeconomic, clinical, and biochemical data were collected through interviews, clinical assessment, and biochemical analysis.

#### *Process indicators*

At the end of the second year of program implementation, 112 community demonstration gardens, 296 school vegetable gardens, and 22,630 household vegetable gardens had been established; 380,000 free fruit seedlings had been distributed; and 1,912 households were engaged in improved poultry raising

#### *Midterm impact assessment*

A midterm impact assessment survey was conducted by World Vision Ethiopia in May 2000 [4]. The survey was carried out in six project areas, and a total of 3,161 households were involved. The survey indicated significant changes from baseline in clinical indicators of vitamin A deficiency. For example, the prevalence of Bitot's spots in preschool children decreased from 6.4% ($N$ = 1,246) at baseline to 0.88% ($N$ = 2,039) at midterm ($p < .001$). In school-aged children (6–14 years), the prevalence of Bitot's spots decreased from 7.5% ($N$ = 3,009) at baseline to 2.3% ($N$ = 1,502) at midterm ($p < .001$). However, it should be noted that the observed improvements in vitamin A status may not be attributable to promotion of vitamin A–rich foods alone. As described above, the World Vision Ethiopia Micronutrient Program has employed a mix of strategies that also includes vitamin A supplementation and primary health care. It can be assumed that the observed improvements in vitamin A status could be the cumulative effect of all approaches. In fact, the main objective of the midterm evaluation survey was not to do an analytical assessment of the impact of the strategy, which would be very difficult in a multiapproach intervention like that of Micronutrient Initiative. Rather, it was aimed at making an overall impact assessment of the World Vision Ethiopia program.

### Challenges

Problems encountered during implementation include shortage of water, recurrent drought in some project areas, and the rising cost of imported vegetable seeds.

### Lessons learned

Production of vitamin A–rich foods was successfully integrated into existing development programs by World Vision Ethiopia and the six partner nongovernmental organizations. Community participation at all levels of the project activity was very encouraging, and the acceptance of backyard gardening by the community was particularly high. A successful collaboration among seven nongovernmental organizations (including World Vision Ethiopia) and more than five government institutions for the noble cause of fighting "hidden hunger" was demonstrated. Local capacity in implementing micronutrient programs was also developed by the nongovernmental organizations as well as by government institutions.

## Conclusions

Production and consumption of vitamin A–rich foods should be given due attention when designing micronutrient programs, particularly in developing countries. People should be encouraged to develop the practice of eating healthy diets instead of depending on nutritional supplements. On the other hand, a food-based approach and, particularly, growing food crops at the household level are already part of the culture of rural communities, and introducing micronutrient-rich vegetables and fruits can be feasible.

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# An integrated primary health-care and provitamin A household food-production program: Impact on food-consumption patterns

Mieke Faber, S. Venter, M. A. S. Phungula, and A. J. S. Benadé

## Abstract

*Food diversification is a long-term food-based strategy to address vitamin A deficiency. In order to improve the vitamin A status of preschool children in a rural South African community, a home-based food-production program targeting provitamin A–rich foods was integrated with a community-based growth-monitoring system. This integrated system provided the infrastructure needed for nutritional education and promotion of the food-production program. Dietary intake was collected by 24-hour recall at baseline and 12 and 20 months after implementation of the food-production program. At baseline, the median intake of vitamin A was 150 µg RE. One year after implementation, the vitamin A intake increased to 1,133 µg RE in children from households with a project garden and to 640 µg RE in control children. Eight months later, vitamin A intake was 493 µg RE in children from households with a project garden and 129 µg RE in control children. We concluded that a home-based food-production program resulted in a significant increase in vitamin A intake. Home gardens should therefore be promoted, but they should focus on foods needed to address specific nutrient deficiencies.*

## Introduction

Vitamin A deficiency continues to be a major health problem in developing countries. Vitamin A, in addition to its essential role in vision and eye health, is recognized as a critical factor in child health and survival [1]. Vitamin A can be obtained from supplements or from foods that are either fortified or naturally rich in vitamin A and provitamin A. Three broad strategies—supplementation through high-dose capsules, food fortification, and food diversification—are explored worldwide for combating vitamin A deficiency, especially in children.

Food diversification is a long-term food-based strategy to address micronutrient deficiencies, such as vitamin A deficiency. The aims of these strategies include an increase in the production of, availability of, and access to foods rich in vitamin A and an increase in the consumption of foods rich in vitamin A, which can be achieved through nutritional education, promotion, and social marketing. A discussion paper by Ruel and Levin [2] stated that home-garden interventions were most effective when combined with promotional and education interventions. The problem in many rural areas in South Africa, and probably in many other African countries, is a lack of infrastructure to be used for education and promotion interventions.

In this paper we describe how a home-based food-production program targeting provitamin A–rich foods was integrated with a primary health-care activity, in this case a community-based growth-monitoring system. This integrated system provided the infrastructure needed for nutritional education and promotion.

The aim of this study was to evaluate the effect of this integrated program on the dietary intakes of children aged two to five years in a rural South African community known to have a high prevalence of low vitamin A status [3].

## Subjects and methods

### Population

The study population resided in Ndunakazi, a mountainous rural area approximately 60 km northwest of the coastal city of Durban in KwaZulu-Natal, South Africa.

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## Integrated primary health-care and provitamin A household food-production program

A combination of primary health-care, educational, nutritional, and agricultural activities was integrated into one program aimed at improving household food security.

### Primary health care

A community-based growth-monitoring system was established in the area in 1995 [4]. It is supported by the community and is based on the needs of the community. The program is run by nutrition monitors (local people specifically trained for the project) through nine home-based centers (*Isizinda*) within the experimental community and five *Isizinda* in the adjacent control area. As part of their contribution towards the project, families make their homes available on a voluntary basis, once a month, to serve as a meeting point for mothers and children. Each *Isizinda* was chosen by the community to serve a particular geographical area. Preschool children in the area attend monthly growth-monitoring sessions held at the *Isizinda*. Anthropometric measurements include height/length and weight. Morbidity and mortality data are collected, minor ailments are attended to, and children who show growth-faltering or are in need of medical attention are referred to the nearest clinic and followed up by the nutrition monitors.

### Education

Basic education concerning nutrition and health problems and the methods of preventing and controlling these problems is given by the nutrition monitors during the monthly growth-monitoring sessions. Sound nutrition is strongly promoted, and the educational messages are action orientated, specific, relevant to the community, and according to World Health Organization (WHO) [5] and WHO/UNICEF [6] guidelines.

### Promotion

At the nine *Isizinda* in the experimental area, the production of yellow fruits and vegetables and dark-green leafy vegetables at the household level is promoted, and daily consumption of these food items is strongly recommended. The nutritional education component at these *Isizinda* focuses on messages related to the relationship between vitamin A and the health of children in an attempt to explain the importance of these food items and to motivate people to participate in the home-based food-production program.

The children are introduced to provitamin A–rich vegetables when attending the monthly growth-monitoring sessions at these nine *Isizinda*. Locally produced vegetables are prepared and fed to all children attending the growth-monitoring sessions. The types of vegetable depend on the season and range from orange vegetables (butternut squash, orange-fleshed sweet potato, and carrots) to dark-green leafy vegetables (spinach). The mothers are taught how to prepare these food items. Grating of carrots and the addition of a little bit of fat is strongly recommended. For the smaller child, the mothers are taught to mash the vegetables.

### Agriculture

As part of the food-production program, a 10 m x 10 m demonstration garden was established at each of the nine *Isizinda* in the experimental area. The demonstration garden is divided into plots the size of a door. These gardens serve as training centers for all mothers attending the growth-monitoring sessions. Skills acquired by the mothers are then applied in their home gardens. The following foods are planted in the demonstration gardens and at the household level: butternut squash, carrots, an orange-fleshed sweet potato, and spinach. Each garden also has a pawpaw tree. Cyclic production and crop rotation are promoted to ensure an adequate supply of provitamin A–rich foods throughout the year.

## Sampling

### Baseline

Before the implementation of the food-production program, all children aged two to five years who attended growth-monitoring sessions at the nine *Isizinda* in the experimental area and the five *Isizinda* in the control area were recruited and their dietary intake was assessed.

### Dietary survey: February–March 2000

One year after the implementation of the food-production program, a sample of 100 children aged two to five years who attended the *Isizinda* during February and March 2000 was selected. Of these children, 50 were from households with a project garden (home gardens producing provitamin A–rich fruits and vegetables), and 50 were from households without a project garden (controls).

### Dietary survey: November 2000

Eight months later, another sample of 100 children aged two to five years was selected. Of these children, 50 were from households with a project garden and 50 were from households from the adjacent control area.

For the use of a single 24-hour recall, a minimum of 50 children per group is required. It was calculated that 50 children per group would be sufficient to show a significant difference in vitamin A intake of at least 300 RE at a 5% significance level with 80% power.

### Ethics

This study was part of a home-based food-production program targeting β-carotene–rich fruits and vegetables to address vitamin A deficiencies in children. Ethical approval was obtained from the Ethics Committee of the South African Medical Research Council. Written informed consent was obtained from each mother or guardian after she was given a detailed explanation of the purpose of the study.

### Dietary intakes

The mother or principal caretaker (a member of the household, usually the grandmother of the child, in whose care the child was during the day) was interviewed by a nutrition monitor in her mother language (Zulu).

Dietary intakes for the children were quantified using the 24-hour recall method. Fresh food, food models, household utensils, and sponge models were used for quantifying and recording food intake. In addition, dry oats were used to quantify the portion sizes of certain food items. The caregiver used the dry oats to indicate the quantity resembling the amount of food consumed by the child, which the nutrition monitor then quantified using a measuring cup. Food intake reported in household measures was converted into weight by using the Medical Research Council (MRC) food-quantities manual [7]. The SAS software package was used to convert food intake to macro- and micronutrients, using the MRC food-composition tables [8] as a food database.

The use of a single 24-hour recall can easily miss the consumption of certain food items. These foods may be excellent sources of a specific nutrient that can be stored in the body but that is not consumed daily, for example, vitamin A, which is stored in the liver. Consequently, an unquantified, previously tested food-frequency questionnaire [9] was used to record the frequency of consumption of specific food items, with the focus on animal products and provitamin A–rich fruits and vegetables. The frequency of consumption of prespecified food items was recorded using the past month as guideline, with the participants having a choice of five options: every day, most days (not every day, but at least four days per week), once a week (less than four days per week, but at least once per week), seldom (less than once a week), and never.

The sources of various β-carotene–rich fruits and vegetables for the month prior to the survey were determined by questionnaire.

### Data analysis

The data were analyzed by univariate and frequency analysis, using the SAS statistical package version 6.12 (SAS Institute, Cary, NC, USA). Vitamin A intakes are given as the medians and the 25th and 75th percentiles (Q1–Q3; interquartile range), since the data had skewed distributions. The difference in vitamin A intake between groups was tested for by analysis of variance.

## Results

### 24-hour recall

The baseline dietary intakes of the children from the experimental and control areas were similar and are therefore grouped together. The children in this rural area consumed a cereal-based diet, the staple foods being phutu (a traditional food of black South Africans made with maize meal into a stiff porridge), bread, and rice. Legumes, mostly beans, formed an integral part of the diet. Food intake was limited to 44 food items.

Vitamin A intake at baseline, one year after implementation (February–March 2000), and during November 2000 is given in table 1. Children from households with a project garden had significantly higher dietary vitamin A intakes ($p < .05$) than children from households without a project garden during both follow-up surveys.

The fruits and vegetables reported during the 24-hour recall period are listed in table 2. The fruits and vegetables reported during the baseline survey did not show a significant decline (except for a slight decline in cabbage) and were therefore not replaced; provitamin A–rich foods were therefore added to the diet. Data collected one year after implementation showed that the consumption of imifino (a locally grown dark-green leafy vegetable) and butternut squash or pumpkin increased in both groups, although more in those children from households with project gardens. The control children consumed mostly pumpkin (a food locally grown before the onset of the program), whereas the children from households with project gardens consumed mainly butternut squash (a food introduced by the program). Yellow vegetables were not reported during the 24-hour recall period during November 2000 except for carrots, which were reported for 6% of the children from households with project gardens.

### Sources of β-carotene–rich fruits and vegetables

Imifino and pumpkin (foods produced in the area before the implementation of the food-production program) were obtained from the family's own home garden. For children from households with project gardens, the gardens were the main source of butternut squash, carrots, spinach, and sweet potato. For control children, these fruits and vegetables were

TABLE 1. Vitamin A intake in children aged two to five years as determined by a 24-hour dietary recall at baseline, and 12 and 20 months after the implementation of a home-based food-production program

| Subjects | N | Vitamin A intake (µg RE) Median | Interquartile range (Q1-Q3) | $p^a$ |
|---|---|---|---|---|
| Baseline (Feb 1999) | 154 | 150 | 56–579 | — |
| Feb–Mar 2000 | | | | |
| With gardens | 50 | 1133 | 636–1765 | 0.0004 |
| Without gardens (controls) | 50 | 640 | 372–1039 | |
| Nov 2000 | | | | |
| With gardens | 50 | 493 | 87–738 | 0.0107 |
| Without gardens (controls) | 50 | 129 | 67–266 | |

*a.* Difference between children from households with and without project gardens, as determined by analysis of variance.

TABLE 2. Percentage of households reporting consumption of vegetables and fruits by children aged two to five years during the 24-hour recall period at baseline, and 12 and 20 months after the implementation of a home-based food-production program

| Food | Baseline (N = 154) | Feb–Mar 2000 Households with gardens (N = 50) | Feb–Mar 2000 Control households (N = 50) | Nov 2000 Households with gardens (N = 50) | Nov 2000 Control households (N = 50) |
|---|---|---|---|---|---|
| Vegetables | | | | | |
| Cabbage | 37 | 14 | 28 | 22 | 50 |
| Imifino | 18 | 64 | 48 | 22 | 14 |
| Spinach | — | — | — | 28 | — |
| Pumpkin or butternut squash | 12 | 72 | 50 | — | — |
| Sweet potato | — | 14 | — | — | — |
| Carrot | — | 8 | — | 6 | — |
| Fruits | | | | | |
| Banana | 26 | 28 | 18 | 12 | 20 |
| Orange | 26 | 30 | 22 | 22 | 44 |
| Apple | 4 | 2 | 8 | 16 | 6 |
| Pawpaw | — | 2 | — | 2 | — |
| Peach | — | 6 | — | 6 | — |
| Mango | — | 4 | — | — | — |

mostly bought (mainly butternut squash and carrots) or obtained from family, friends, and neighbors (especially pawpaw and sweet potato). Peaches and mangoes were mainly bought.

## Discussion

The community-based growth-monitoring system was established in 1995. During 1999, this primary health-care activity was integrated with a home-based food-production program, thereby providing the infrastructure for nutritional education and promotion. The *Isizinda* provide an ideal opportunity for promoting such community projects, as they provide captive audiences. In addition, the *Isizinda* serve as demonstration and training centers for the agricultural activities. The integration of these activities resulted in a multisectoral community program containing primary health-care, agricultural, nutritional, and educational activities. The program was an outcome of several objective-oriented program-planning exercises that was attended by various community members, and it was established with the support and participation of the community.

Before the implementation of the food-production program, the children in this rural area consumed a cereal-based diet, the staple foods being phutu, bread, and rice. Legumes, mostly beans, formed an integral part of the diet. The diet lacked variety, and food intake was limited to 44 food items. Low dietary intakes of foods rich in vitamin A and provitamin A were reflected in low serum retinol levels, with half of the children presenting with serum retinol levels below 20 μg/dl (authors' unpublished data).

The food-production program added variety to the diet and did not replace a major component of fruits and vegetables previously consumed (cabbage, banana, and orange). The intake of provitamin A–rich foods increased, resulting in a significant increase in dietary vitamin A intake. The data suggest that there is a seasonal effect, since the median vitamin A intake in children from households with project gardens was substantially higher during February–March 2000 as compared with the median intake in November 2000. February–March is the harvesting period for yellow vegetables, namely, pumpkin, butternut squash, and orange-fleshed sweet potatoes. Although spinach is not available during this period, the consumption of a locally grown dark-green leafy vegetable (imifino) increased. During November, some of the imifino was replaced by spinach, which was then in season. The intake of vitamin A was much lower during this period, since yellow vegetables were not freely available at that time of the year.

The impact of the food-production program was seen mainly in the consumption of vegetables. The intake of imifino increased, and spinach was added when in season. In addition to the increased intake of dark-green leafy vegetables, a yellow vegetable was added when in season. Although imifino and pumpkin are not produced in the project gardens, the intake of these locally produced food items increased because of the awareness created by the program. We have previously shown that although these food items were locally produced, the quantities that were grown and eaten were low [10].

The food-production program did not have a major impact on fruit intake. Although three fruits were promoted (pawpaw, yellow peach, and mango), these fruits were reported during the 24-hour recall period for a small percentage of the children only.

The food-production program may well have important effects other than increased vitamin A consumption, such as improved intakes of other nutrients as well as the generation of income from the sale of vegetables. The food-production program has a strong element of skills development, empowering the community to social upliftment.

The experimental and control areas are adjacent to each other. The program created an awareness in both areas, which resulted in the increase in vitamin A intake in the control children during the first follow-up survey. This increased intake in children from households without a project garden was a result of the awareness created by the visibility of the demonstration and project gardens, the availability of butternut squash in the shops as an outcome of the program, and the negotiations to obtain provitamin A–rich fruits and vegetables.

Retinol-rich foods of animal origin are most effective in improving vitamin A status. These food items are, however, expensive. Fruits and vegetables are a more affordable option. In Bangladesh, it was shown that provitamin A–rich fruits and vegetables can provide a valuable contribution to vitamin A intake in communities where alternative dietary sources of vitamin A are scarce [11].

Preliminary results showed that the food-production program resulted in a significant improvement in vitamin A status, since children in the experimental area had statistically significantly higher serum retinol levels than children from the control area, with children from households with project gardens having significantly higher serum retinol levels than children from households without project gardens within the experimental area (authors' unpublished data).

At a workshop on prevention and control of micronutrient malnutrition through food-based actions of countries of the South Asian Association for Regional Cooperation (SAARC) held in Dhaka, Bangladesh in 1997, it was agreed that "it is necessary to look at farms and not pharmacies for the solution of nutritional problems." An outcome of this workshop was the recommendation that home gardening should be promoted more extensively, selecting fruits and vegetables rich in micronutrients [12].

In conclusion, an integrated, community-based, primary health-care and food-production program targeting provitamin A–rich fruits and vegetables resulted in a significant increase in vitamin A intake. The promotion of home gardens is strongly recommended, provided that they focus on those food items needed to address specific nutrient deficiencies in a specific community.

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# Enhancing vitamin A intake in young children in western Kenya: Orange-fleshed sweet potatoes and women farmers can serve as key entry points

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## Abstract

*In western Kenya, where vitamin A deficiency is common and the white sweet potato is an important secondary staple, orange-fleshed sweet potatoes were introduced and their consumption was promoted, along with other vitamin A–rich foods. Ten women's groups grew a number of varieties of sweet potato on group plots in on-farm trials. Five of the groups also received an intervention consisting of nutritional education, individual counseling, and participatory rapid appraisal techniques to promote vitamin A consumption, while the other five formed the control group that received no additional promotion. Changes in consumption of children under five years of age were assessed before and after a one-year intervention period using the Helen Keller International food-frequency method. Varieties were tested for yield, agronomic performance, taste and appearance, and dry matter content. They were also assessed for β-carotene content in the forms of boiled and mashed puree, sweet potato flour, and processed products. Children in the intervention group consumed vitamin A–rich foods almost twice as frequently as control children (93% more), especially orange-fleshed sweet potatoes, mangoes, dark-green leafy vegetables, butter, and eggs. The yields of orange-fleshed sweet potatoes were at least twice those of white sweet potatoes, as were the taste and appearance ratings. The dry matter content of the varieties exceeded 25%, except for one that was preferred as a weaning food. β-Carotene values were high enough that one cup of boiled and mashed sweet potato fed daily to children of weaning age would alone meet their requirement of vitamin A, even using the higher 12:1 β-carotene:retinol conversion. Orange-fleshed sweet potatoes produced and prepared by women farmers can serve as a key food-based entry point for reducing vitamin A deficiency.*

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## Introduction

Subclinical vitamin A deficiency is prevalent throughout Kenya, with extremely low serum retinol levels found primarily in the densely populated western region of the country [1]. The 1994–1996 Kenyan National Development Plan called for the expansion of vitamin A capsule distribution programs to all at-risk children and lactating women, rather than supplementing only those children with clinical signs of deficiency [2]. Another means for addressing vitamin A deficiencies is through the promotion of food-based, agricultural interventions. These are particularly effective in reducing subclinical vitamin A deficiencies and complement supplementation programs. One potential food-based strategy focuses on the promotion of varieties of orange-fleshed sweet potatoes rich in β-carotene as a key entry point for improving vitamin A intake.

Promotion of orange-fleshed sweet potatoes is a logical food-based strategy in Kenya for several reasons. First, they are rich in β-carotene [3]. Although sweet potatoes are a widely cultivated traditional food crop in certain parts of Kenya, the most common varieties currently grown are white-fleshed and therefore low in β-carotene. Vitamin A deficiency is common in western Kenya, the major sweet potato-producing region in the country. Sweet potatoes are eaten as a secondary staple food (following maize, the primary staple) and are boiled whole, mashed with legumes, or eaten with leafy vegetables, meat, or fish [4].

Second, orange-fleshed sweet potatoes have been identified as the least expensive potential year-round source of dietary vitamin A [5]. Although mangoes are the cheapest source, they are widely available during only four months of the year. Cod liver oil is the second cheapest source per retinol equivalent, but it is not widely available in local stores, and even the smallest bottle is too expensive for poor households to afford. In contrast, orange-fleshed sweet potatoes, the third cheapest source, are available year-round, can be purchased in affordable units, and are easily cultivated.

Third, sweet potatoes are cultivated by women, who are also the main actors regarding households food security. The goal of improving vitamin A status through enhanced availability, accessibility, and utilization of foods is more likely to be achieved if women control both production and consumption of a particular crop. Women plant sweet potatoes on small plots of land, weed the vines, and harvest when they choose [6]. They tend to keep most of the harvest for home consumption or to sell small enough amounts that the income earned remains under their control [7].

The introduction of sweet potatoes described in this paper built on three stages of earlier research projects by the Kenya Agricultural Research Institute (KARI) and the International Potato Center (CIP) that identified varieties of orange- and yellow-fleshed potatoes acceptable to consumers and suitable for cultivation in the region [8]. First, preliminary trials were conducted at a field station in order to test the characteristics of more than 40 varieties of germplasm in one type of soil. Second, 10 additional types were grown more widely and their progress monitored. Finally, in the advanced yield trials, 10 varieties of the potatoes were tested in a variety of agroecological zones under experimental conditions. Taste tests revealed that acceptability among adults was correlated with a high content of dry matter (greater than 27%) and with orange color. Five yellow- and orange-fleshed varieties that were approved by producers and consumers and had performed well in the agroecological zones of the study site were then selected for on-farm trials, the focus of the current study.

The conceptual framework shown in figure 1 guided the study design. It suggests that two ways to increase the vitamin A intake of young children are introduction of a new source of the micronutrient into the diet and promotion of increased consumption of existing sources. The framework also indicates that a higher intake of vitamin A could occur through the purchase and consumption of vitamin A–rich foods with income earned from selling sweet potatoes, or through consuming processed foods made with the new varieties of sweet potatoes.

This study examines the potential of promoting orange-fleshed sweet potatoes and other plant and animal sources of vitamin A through women's groups to improve the vitamin A intakes of families in western Kenya, especially among weaning-age children.

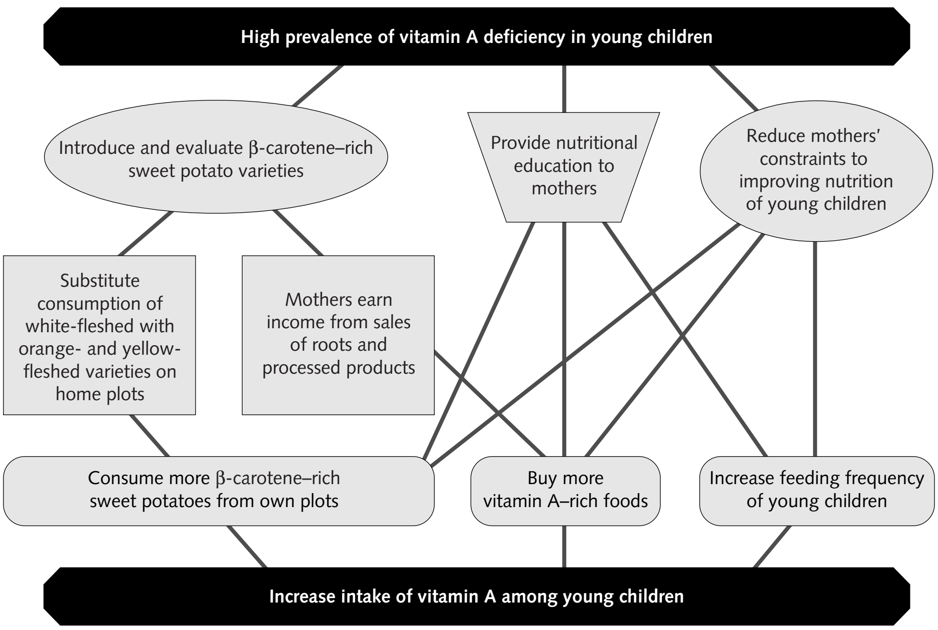


FIG. 1. Conceptual framework

## Study design, intervention, and methods

### Formative phase

The study was conducted in three phases, according to a timeline shown in table 1. First, from September 1995 to April 1996, an evaluation of these sites was conducted, using techniques such as market surveys, key informant interviews, and group discussions about food availability and the feeding practices of young children. These data were used to select the sample communities and design the intervention trial.

Three places in Nyanza Province of western Kenya were considered as possible intervention sites because they represent distinct agroecological zones suitable for sweet potato cultivation. Ndhiwa and Nyarongi Divisions were chosen as the principal intervention site, because the climate was suitable for growing at least two crops of sweet potatoes each year. Also, socioeconomic status and health indicators suggested that communities in Ndhiwa and Nyarongi were not well-off compared with neighboring districts, with relatively poor access to markets and services. Women's groups closer to an active marketing zone were selected for a secondary intervention site, Rongo. The testing of commercial potential of processed sweet potato-based products was done with these groups. However, since the initial mean Helen Keller International group scores indicated much higher levels of vitamin A intake, they are not included here, but can be found elsewhere [5, 9]. A community-based assessment was conducted in October 1995 to determine the extent of vitamin A deficiency in Ndhiwa and Nyarongi.

### Intervention phase

The second phase, from April 1996 to June 1997, was a one-year intervention trial that included widespread distribution of sweet potato vines and nutrition promotional activities. The intervention trial was carried out through women's groups, which were chosen as the unit of implementation and analysis in this study for several reasons. First, women's groups are common throughout Kenya and widely recognized as grassroots units through which change can be initiated and implemented, particularly with regard to family food production and nutrition. Second, the sweet potato is considered a woman's crop, because it is cultivated and harvested primarily by women, making women's groups in rural areas a useful entry point for testing new varieties in on-farm trials. All 10 women's groups that were active in Ndhiwa and Nyarongi were asked and agreed to participate in on-farm trials and receive visits from agricultural extension staff.

Trials of new sweet potato varieties conducted by KARI and CIP in 1994 led to the identification of

TABLE 1. Time frame for selected project activities in Ndhiwa[a]

| Activity | Time frame |
|---|---|
| *Short rains: maize and beans planted* | *Oct–Nov 1995* |
| Baseline prevalence survey using Helen Keller International (HKI) food-frequency questionnaire administered in 15 communities | Oct 1995 |
| *Sweet potatoes planted (on-farm and advanced-yield trials)(first round)* | *Nov 1995* |
| Preintervention HKI food-frequency questionnaire administered to all 10 women's groups | Feb–Mar 1996 |
| *Long rains: maize and beans planted* | *Mar–Jun 1996* |
| Harvest and taste evaluation conducted on first round of crops in advanced-yield and on-farm trials | Mar–May 1996 |
| Intensive intervention in groups | Apr 1996–Jun 1997 |
| *Sweet potatoes planted (second round)* | *Jun 1996* |
| *Sweet potatoes planted (third round) during short rains (very short)* | *Nov 1996* |
| *Long rains (normal duration)* | *Mar–Jun 1997* |
| Postintervention HKI food-frequency questionnaire administered to all 10 women's groups | Jul 1997[a] |

*a.* Because vitamin A–rich foods are highly sensitive to seasonal variations, baseline and postintervention data should have been collected in the same calendar months. However, because of a drought that occurred during the intervention period, the postintervention data (July 1997) were comparable to baseline (April 1996) data in terms of availability of vitamin A–rich foods. Italics indicate seasonal events.

many orange- and yellow-fleshed potatoes suitable for cultivation in the study areas. The research team selected five varieties that were most promising for distribution and planting by the women's groups in the on-farm trials. In addition, the women's groups selected one popular local variety to compare (the local check variety). In October 1995, the selected sweet potato varieties were distributed for planting during the short rainy season. Fertilizers, insecticides, and fungicides were not applied to the crops, a decision that was consistent with sweet potato cultivation practices in the area. Agricultural extension agents visited the farmers at three points in time (planting, midseason, and harvesting) to support the adoption of the sweet potato varieties.

The study design also called for half of the women's groups (intervention group) to be purposively allocated to receive nutrition promotional activities from a project-hired fieldworker, while the other half (control group) received no intervention beyond participation in the on-farm trial of sweet potatoes. The intervention group was matched with the control on preintervention frequency scores of vitamin A–rich foods consumed in the previous week and on distances traveled to the local market.

The promotional nutrition activities consisted of nutritional education administered in the women's groups, including training in food processing techniques; facilitated group discussions using participatory rapid appraisal (PRA) methods to assist community members to identify ways to enhance use of the new sweet potato varieties toward reducing vitamin A deficiency; and nutritional counseling to individuals from the women's groups through monthly home visits by the study fieldworker. The combination of working with groups to present information and to encourage discussion of application possibilities, and then following up with individuals to identify and overcome application constraints, was chosen to optimize efficiency and effectiveness [10, 11].

Nutritional education techniques included flipcharts and other visual aids, and the training in sweet potato processing included practical demonstrations. Five key messages were emphasized: vitamin A helps prevent severe disease and protects eyesight; many local foods contain vitamin A; dietary fat enhances vitamin A absorption; breastmilk and colostrum are good sources of vitamin A, and no other foods are needed for the first six months of life; and young children need to be fed more frequently than adults. These messages were derived from the qualitative data-collection portion of the Helen Keller International (HKI) methodology.

The PRA discussions on how best to use the new sweet potato varieties explored the following options: enhancing existing weaning foods through addition of sweet potato; selling fresh roots in local or distant markets; processing sweet potato into products for home consumption or sale; establishing rapid multiplication plots for increased production of planting material throughout Ndhiwa and Nyarongi districts; acquiring technologies for storing fresh roots or dried chips; and improving agronomic practices.

Finally, the study fieldworker made monthly home visits to peform individual nutritional counseling and monitor various aspects of the study. She assessed how the women were applying what they had learned from the nutritional education and facilitated discussions, and she identified and helped overcome constraints. For example, she helped one woman weigh the encouragement of exclusive breastfeeding from the nutritional education against her mother-in-law's insistence that giving water to newborns encourages them to breastfeed. The fieldworker monitored the care that women's groups were taking of their sweet potato plots and assisted the agricultural extension workers in monitoring the yields. Although 12 monthly visits were made to individual women, not all were used for nutritional counseling.

### Evaluative phase

Patterns of children's consumption of vitamin A–rich foods were assessed using the HKI food-frequency method. This method scores the number of days during the previous week that children under five years of age were reported to have consumed animal and plant foods rich in vitamin A. According to Helen Keller International guidelines, communities with an animal source index of less than four days per week or a mean weighted total food-frequency index of less than six days per week are considered at risk for vitamin A deficiency [12]. Young children are considered to be at greatest risk for the unfavorable outcomes of vitamin A deficiency and are therefore the most sensitive group in which to detect that deficiency exists within communities. For groups of children, though not for individuals, cutoffs with this method indicate the risk of vitamin A deficiency, based on earlier validation of average weighted food frequency of vitamin A–rich foods in communities against average serum retinol values in communities [12]. The validation occurred even when breastmilk was not included on the frequency list as a vitamin A–rich food [13]. The HKI food-frequency method was used to assess whether Ndhiwa and Nyarongi were at risk of vitamin A deficiency, and to detect changes in the frequency of feeding vitamin A–rich foods to young children from before (baseline) to after the intervention. Analsis of variance (ANOVA) was conducted using SPSS statistical software to compare HKI scores between the intervention and control groups in each community before and after the intervention.

PRA methods [14, 15] were used to investigate the control over vitamin A–rich food sources and inputs used for sweet potato production, the extent of consumption or sale of vitamin A–rich foods among study households, and adoption of the new varieties by men. This is in addition to the use of PRA for discussing how best to use the new sweet potato varieties mentioned above. Women and men were asked questions about decision-making on land access and use, the cultivation and harvesting of orange-fleshed sweet potatoes, and the spending of profits.

The total carotenoid, β-carotene, and dry matter contents of fresh roots of the sweet potato varieties grown and of selected processed food products were measured. Total carotenoid and β-carotene contents were measured by column chromatography and spectrophotometric methods [16]. Dry matter was determined by oven-drying samples of freshly chopped roots [17].

Sweet potatoes from the on-farm plots were harvested in April and May 1996, and data were collected on yield and damage by weevils and moles. The potatoes were then evaluated for their agronomic performance. In addition, roots were steamed so that local women and men could assess their appearance and taste. The project participants and the research team assigned a general satisfaction rating to the varieties based on growing and handling performance.

## Results

### HKI food-frequency scores

Results from the prevalence survey conducted in the Ndhiwa and Nyarongi in October 1995 clearly indicate that vitamin A deficiency is a critical public health problem in this area of Kenya. Detailed results from this phase of the study have been published elsewhere [5]. In the 15 communities surveyed, the main weighted total food frequency of vitamin A–rich foods was four days per week, well below the threshold of 6.0. The mean frequency of consumption of animal sources of vitamin A was three days per week, which is also below the threshold of 4.0. Foods cooked in oil were the major sources of fat (served on average 3.3 days/week), the major source being home-prepared ghee (butter).

To assess the effects of the intervention, the HKI food-frequency questionnaire was administered before and after the intervention in the households of members of 10 women's groups in Ndhiwa and Nyarongi. The members had a total of 154 children five years of age or under. Baseline (preintervention) scores were similar for both the intervention and the control groups (fig. 2). HKI scores in the intervention group increased significantly (+1.6 points) from pre- to postintervention, whereas the control group scores decreased (–1.3 points). The net increase in HKI scores in response to the intervention was therefore 2.9 points. This change represents a 93% increase over the preintervention level and was highly significant (ANOVA $p = .0015$ for the intervention period- interaction term). HKI methodology was applied to all women group members present postintervention with a child under six years of age, whether or not they were present at the time of the initial survey (39% of control group members and 61% of intervention group members were present at the time of the initial survey). That is, the unit of analysis was the women's group. If the woman had more than one child, the child to be interviewed was randomly selected (thus assuring a sample of children well distributed in terms of age). Comparison of means (ANOVA, $p < .005$) of key HKI indicators from the subsample of women's group members present for both the pre- and post-interviews with the entire group of women interviewed postintervention indicates that no significant bias was introduced by including all women group members in the assessment (for example, the total mean weighted score for the entire control sample was 2.96 vs. 2.91 in the subsample; 5.80 in the entire intervention sample vs. 5.59 in the sub-sample). Membership in women's groups in Kenya is dynamic, and the evidence indicates that incoming members were adequately exposed to the basic intervention messages.

The animal and plant food components of the HKI scores are shown in figure 3. The animal component scores follow a pattern similar to that of the total HKI scores. The intervention group score increased greatly (+1.0 points) from pre- to postintervention, whereas the control group score decreased (–1.7 points), resulting in a net highly significant increase of 2.7 points (ANOVA $p = .0015$ for the intervention period-inter-

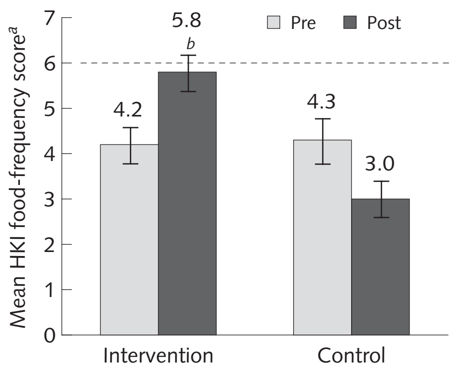


FIG. 2. Frequency of consumption of vitamin A-rich foods among 154 children zero to five years of age.

*a.* Calculated as days of consumption of animal food sources/week + [(days of consumption of plant food sources/week)/6]; values below 6 are suggestive of vitamin A deficiency.

*b.* The increase from the pre- to the postintervention period was significantly greater in the intervention group (+1.6) than the decrease in the control group (–1.3)(ANOVA, $p = .0015$)

action term).

The plant component of the score also increased and was statistically significant (ANOVA $p = .01$ for the intervention and period main effects terms). The pattern of scores for plant foods differed from that for animal food scores, with both intervention and control groups showing higher scores in the postintervention period.

Increases in the animal component contributed the major portion of change in the total HKI scores due to higher consumption of ghee and egg yolks (table 2). The use of purchased sources of vitamin A, such as fortified margarine, commercial weaning foods, and cod liver oil, was rare.

The increase in the plant scores in both the intervention and the control groups was due in large part to higher consumption of orange-fleshed sweet potatoes, which may have replaced some cassava consumption. Consumption of white-fleshed sweet potato did not change significantly. Mangoes and dark-green leafy vegetables also contributed to the increased plant scores. The significantly higher consumption of sweet potato leaves in the intervention group is notable, because prior to the intervention the leaves were considered only animal food.

The results indicate that frequent feeding (at least four times a week) of orange-fleshed sweet potatoes occurred in only 22% of intervention households. This value was far superior to the 6% for control households (table 3), but it was less than expected, for several possible reasons. The orange-fleshed sweet potatoes were still in the process of being multiplied in sufficient quantities. A drought occurred during the short rains of late 1996, which diminished the amount of material available for planting in the long rains just prior to the evaluation. Although sweet potatoes are fairly drought resistant once established, the vines used as planting material are less so. Consequently, only 23% of the Ndhiwa and Nyarongi households had expanded the area under sweet potato produc-

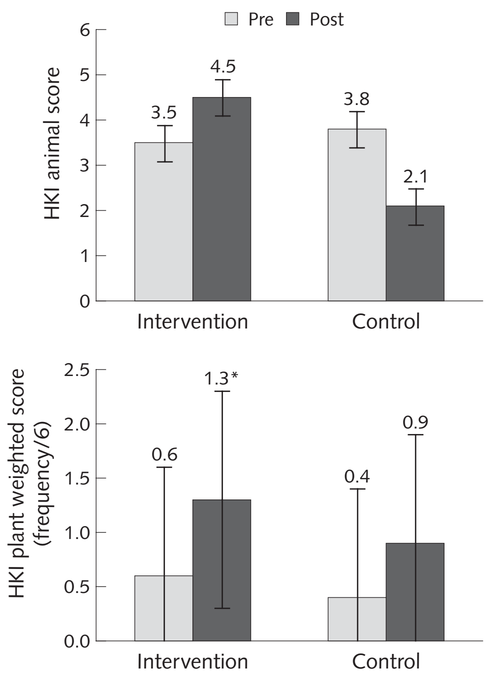


FIG. 3. Animal and plant components of Helen Keller International scores in Ndhiwa and Nyarongo.

* The increase from the pre- to the postintervention period was significantly greater in the intervention group than in the control group (ANOVA, $p = .0015$)

TABLE 2. Mean frequency of consumption (number of days eaten during the past week) of different ingredients by children under six years of age in Ndhiwa and Nyarongi, postintervention

| Ingredient | Control ($N = 35$) | Intervention ($N = 41$) |
|---|---|---|
| Major plant sources of vitamin A | | |
| Orange or yellow sweet potato* | 1.11 | 220 |
| Ripe mango* | 0.29 | 100 |
| Pumpkin (squash)* | 23 | 95 |
| Ripe papaya | 0.60 | 0.61 |
| Dark-green leafy vegetables** | 1.49 | 3.61 |
| Sweet potato leaves* | 0.57 | 1.15 |
| Major animal sources of vitamin A | | |
| Egg yolk* | 1.20 | 1.78 |
| Liver | 0.54 | 0.78 |
| Red meat | 0.83 | 0.76 |
| Whole small fish | 2.26 | 1.9 |
| Cod liver oil | 0.00 | 0.12 |
| Ghee** | 0.26 | 1.34 |
| Other foods | | |
| Groundnuts | 0.71 | 1.1 |
| Cassava** | 2.69 | 0.95 |
| White-fleshed sweet potato | 0.57 | 0.95 |
| Diluted cow's milk** | 5.60 | 2.27 |

$*p < .05$, $**p < .001$, for the difference between mean values for control and intervention groups (analysis of variance).

TABLE 3. Percentage of children consuming orange or yellow-fleshed sweet potato on different numbers of days during the previous seven days

| No. of days | % of children | |
|---|---|---|
| | Control ($N = 35$) | Intervention ($N = 41$) |
| 0 | 51 | 17 |
| 1 | 17 | 17 |
| 2 | 14 | 22 |
| 3 | 11 | 22 |
| 4 | 3 | 20 |
| 5–7 | 3 | 2 |

tion, whereas others decreased or did not change. No significant differences between control and intervention groups were seen in the amount of area planted postintervention. The principal reason cited for not increasing the area under production was lack of planting material. Another possibility was that orange-fleshed sweet potatoes were being sold, as over two-thirds of households in both intervention and control groups reported doing to some extent. Although the respondents reported numerous purchases due to sweet potato sales, these did not include purchase of vitamin A–rich foods such as eggs. The entire sample ($N$ = 76) did report on whether money from sweet potato sales was ever spent on salt or sugar (71%), health care (68%), school fees (14%), furniture (14%), cattle (0%), other livestock (11%), renting or buying land (1.3%), buying fertilizer or chemical inputs (0%), or paying brideprice (0%).

The results indicate the importance of the food-promotion activities of the intervention. The sweet potatoes served as a particularly effective entry point for working with caregivers on improving child-feeding practices. The nutrition component not only served to increase the frequency of consumption of vitamin A–rich foods but also improved other feeding practices. For example, mothers in the intervention group decreased the frequency of diluting milk with water before serving it to children (table 2).

### On-farm trials of new sweet potato varieties

Several of the sweet potato varieties tested in the on-farm trials performed well in terms of yield and consumer acceptability. The yield ranged from 4.5 to 11.2 tons per hectare (see table 4). The highest overall yields were obtained with the Simama, Pumpkin, and Japonese varieties, whereas the worst performance was observed with the local check varieties. Participating farmers also assigned a general satisfaction rating to the sweet potato varieties with regard to overall agronomic performance. On a scale of 1 to 5 (with 1 being very bad), ratings ranged from 1.6 for the local check variety in Ndhiwa and Nyarongi to 3.1 for the Pumpkin potato. The results of agronomic evaluations from researchers and farmers were similar.

The taste tests and appearance evaluations of cooked sweet potatoes also indicated that the Kakamega 4, Simama, Pumpkin, and Japonese varieties were acceptable to community members (table 4). As expected, the local check varieties ranked high in terms of taste and appearance. The Maria Angola variety ranked last in terms of appearance and taste and was therefore eliminated from further cultivation and distribution efforts.

With the exception of the Pumpkin variety, the dry-matter content of these sweet potatoes exceeded 25%, a level that correlated well with adult consumer acceptance in previous taste tests. By contrast, Pumpkin was preferred by mothers and children because its mushy texture made it easier to add to other locally available weaning foods and therefore easier for children to consume, and because it required less time and fuel to cook than did other varieties.

### β-Carotene and total carotenoid content

Earlier analyses of 37 varieties of potatoes grown in advanced yield and on-farm trials showed that β-carotene was the major carotenoid. The β-carotene content of most of these orange-fleshed varieties exceeded 100 μg retinol equivalents per 100 g (μg RE/100 g) of dry weight, a good dietary source of pro-vitamin A. Carotenoid content was directly related to color, confirming that color intensity may be used as an indication of pro-vitamin A value in sweet potatoes [18].

Over 40 sweet potato varieties were analyzed for β-carotene content in this study. Orange-fleshed sweet

TABLE 4. Yield, percentage of dry matter, taste ratings by adults, and appearance ratings by adults of cooked sweet potato roots grown in on-farm trials and harvested in March-April 1996[a]

| Variety | Yield (tons/ha) | Dry matter (%) | $N^b$ | Taste: Very good | Taste: Good | Taste: Acceptable to good | Appearance: Bad to very bad | Appearance: Acceptable to very good |
|---|---|---|---|---|---|---|---|---|
| | | | | % of responses | | | | |
| Simama | 11.2 | 33.1 | 108 | 29 | 27 | 30 | 15 | 74 |
| Pumpkin | 9.3 | 19.6 | 109 | 18 | 22 | 31 | 28 | 82 |
| Japonese | 8.7 | 25.3 | 106 | 16 | 26 | 30 | 28 | 69 |
| Kakamega 4 | 8.6 | 28.6 | 94 | 40 | 21 | 19 | 16 | 81 |
| Maria Angola | 7.7 | 27.0 | 108 | 13 | 16 | 37 | 33 | 70 |
| Local check | 4.5 | 34.6 | 79 | 35 | 27 | 23 | 15 | 81 |

*a.* Yield data based on results from 10 on-farm trials. Taste and appearance evaluation scale: 1 = very bad, 5 = very good.
*b.* Number of community participants.

potatoes exhibited a wide range of β-carotene content, with average values found in raw orange-fleshed roots ranging from 258 to 1,338 μg RE/100 g (table 5) [19]. The two yellow-fleshed varieties used in the on-farm trials had low RE values, which was disappointing for Simama because it had the highest yields and dry matter content in the on-farm trials.

### Sweet potato-based processed food products

Processed food products made from new sweet potato varieties were well accepted by food processors and consumers. For those substituting wheat flour, labor costs increased somewhat due to sweet potato processing, but these were more than offset by the savings in reduced expenditure on wheat flour. A cost analysis indicated that substituting sweet potato for wheat flour in mandazis made the product more profitable for market vendors (i.e., a KSh15 profit instead of a KSh47 loss).

Substituting sweet potato for other ingredients dramatically increased the β-carotene content of processed food products (table 6). In chapatis and mandazis, typically 3 units of sweet potato flour are combined with 7 units of wheat flour; for boiled and mashed sweet potato the ratio is 1 kg of sweet potato to 1 kg of wheat flour. The roots were either fresh grated, boiled and mashed into a puree, or processed into flour. Boiling of the roots resulted in a loss of 20% total carotenoid contents of the Pumpkin cultivar, while drying into chips reduced the amount of total carotenoids by 30% compared to the amount in fresh roots. Mandazis, chapatis, and buns made traditionally with wheat flour contained approximately 18 to 20 μg RE per 100 g of food product, whereas the products containing orange-fleshed sweet potato ranged from 91 to 259 μg RE per 100 g, a value 4.5 to 14 times greater. Among the ways to incorporate the sweet potatoes, sweet potato flour appears to be the most effective for increasing the β-carotene content of the processed products.

### Control over resources

Results from the PRA indicate that women generally have control over the small plots of land that their husbands allocate to them at the time of marriage, but have to ask their husbands' permission for access to additional land. Men most often control stored wealth (e.g., livestock or machinery), and most women do not control sufficient cash to hire plows or other farm implements for large-scale crop production. Women usually decide when to plant sweet potatoes, but if their husbands require their assistance to plant cash crops, they must postpone their own planting. Women generally have access within the household to the majority of vitamin A–rich food sources, including the orange-fleshed sweet potato, and can decide whether to prepare them for consumption at home or to sell them. Once the products are sold, women are likely to use the derived income, but they must inform their husbands before doing so. In sum, the potential for

TABLE 5. Carotenoids and vitamin A values (mean ± SD) of selected sweet potato cultivars from Kenya evaluated in 1996

| Cultivar (formal CIP number or name) | Color of flesh | Total carotenoids (mg/100 g fresh root)[a] | β-Carotene (mg/100 g fresh root)[a] | β-Carotene/ total carotenoids (%) | Vitamin A (μg RE/100 g fresh root)[a] |
|---|---|---|---|---|---|
| Simama (KEMB 10) | Light yellow | 0.4 ± 0.0 | 0.1 ± 0.0 | 39.6 | 21.1 ± 1.8 |
| Maria Angola (CIP420008) | Yellow | 0.4 ± 0.0 | 0.1 ± 0.0 | 28.4 | 18.5 ± 1.6 |
| Kakamega 4 (SPK 004) | Orange | 2.6 ± 0.2 | 1.5 ± 0.1 | 59 | 258.2 ± 23.3 |
| Pumpkin (CIP420027) | Orange | 4.3 ± 0.0 | 2.9 ± 0.5 | 67.7 | 493.8 ± 80.2 |
| Japonese (Japon Tresmes-ino Selecto or CIP420009) | Intermediate orange | 5.5 ± 0.3 | 4.6 ± 1.4 | 82.7 | 768.4 ± 228.8 |
| W-220 (CIP440015)[c] | Intermediate orange | 8.4 ± 0.4 | 6.0 ± 0.5 | 71.7 | 1021.3 ± 82.1 |
| TIB 11 (CIP440057)[c] | Orange | 8.8 ± 0.7 | 8.0 ± 0.3 | 90.8 | 1338.2 ± 56.9 |

*a.* Based on HPLC analysis [19] of roots from Kabete, Kenya. RE based on a 6:1 conversion rate of β-carotene to retinol [20] to be consistent with figures published earlier [19].

*b.* Not included in on-farm trials.

TABLE 6. Total carotenoid contents of processed food products containing sweet potato, cultivar Pumpkin (CIP420027)

| Product | Dry matter (%) | Total carotenoids (μg β-carotene equivalent/ 100 g product) | Estimated RE (μg RE/ 100 g product)[a] |
|---|---|---|---|
| Raw material | | | |
| Fresh roots | 21.6 | 4,910 ± 126.3 | 556 |
| Boiled and mashed roots | 18.9 | 3,408 ± 34.6 | 386 |
| Sweet potato flour | 88.7 | 13,929 ± 28.4 | 1,579 |
| "Elianto" cooking oil | 99.5 | 98 ± 17.6 | 16 |
| Chapatis from: | | | |
| Raw and grated | 68.4 | 1,518 ± 198.8 | 172 |
| Boiled and mashed | 60.3 | 1,092 ± 34.6 | 124 |
| Sweet potato flour | 68.6 | 2,282 ± 19.2 | 259 |
| Wheat flour | 69.0 | 111 ± 7.3 | 18 |
| Mandazis from: | | | |
| Raw and grated | 69.5 | 1,485 ± 332.0 | 168 |
| Boiled and mashed | 59.8 | 1,616 ± 90.0 | 183 |
| Sweet potato flour | 66.2 | 2,119 ± 82.8 | 240 |
| Wheat flour | 68.3 | 109 ± 2.7 | 18 |
| Buns from: | | | |
| Raw and grated | 67.2 | 802 ± 21.0 | 91 |
| Boiled and mashed | 66.8 | 1,186 ± 12.0 | 134 |
| Sweet potato flour | 70.3 | 2,228 ± 45.6 | 253 |
| Wheat flour | 69.3 | 117 ± 6.0 | 20 |

*a.* Based on 67% of total carotenoids in pumpkin being in the form of β-carotene, and RE based on a 6:1 conversion rate of β-carotene to retinol [20] to be consistent with figures published earlier [9].

increasing women's income generated through the cultivation of sweet potatoes exists but requires further exploration.

## Discussion and conclusions

The results of this study indicate that orange-fleshed sweet potatoes and sweet potato-based food products not only were acceptable to both producers and consumers in the target communities in terms of appearance, taste, and texture, but also contributed to the alleviation of vitamin A deficiency. Three of the five new sweet potato varieties grown in the on-farm trials performed well with respect to yield and pest resistance and also had a high β-carotene content. In addition, processed food products made by substituting sweet potato for other ingredients were popular. The growing conditions in the study area are favorable for raising several crops of sweet potatoes per year, making the goal of year-round availability of an affordable β-carotene-rich food source highly attainable. However, periodic droughts several months in length mean that farmers have to develop means of safeguarding sufficient planting material.

The main nutritional outcome indicator in this study was the frequency with which children under five years of age consumed vitamin A–rich foods. The increase in HKI scores in Ndhiwa and Nyarongi was sizable after only one year of intervention activities. A net increase of 93% was attained in the scores, and the final score in the intervention group almost reached the recommended threshold of 6.0, which indicates little risk of vitamin A deficiency. However, simply distributing β-carotene-rich varieties of sweet potatoes and providing minimal agricultural support for their production is not sufficient to increase children's frequency of consuming vitamin A–rich foods. In this study, the nutritional education and counseling activities led to the significant increases in children's consumption.

Although the three parts of the intervention to promote consumption of vitamin A–rich foods could not be separated, several aspects of their administration were key to the study's success:

» Following the initial nutritional education and food-processing lessons, the project fieldworker made home visits to members of the women's groups on a monthly basis for a year. The fieldworkers reviewed parts of the lessons as needed and answered questions, which at times involved the reconciliation of nutrition messages with cultural patterns. Without an opportunity to discuss these concerns, women might have been less likely to change the vitamin A consumption patterns of their children and other household members. However, two or three nutritional counseling sessions should be adequate to identify and overcome constraints to applying lessons from the nutritional education, instead of the 12 available to individual women in this study.

- » The women participants responded well to the lessons on how to process orange-fleshed sweet potatoes for use in common foods. The modified snack foods were well liked and sold quickly.
- » The fieldworkers and researchers were attentive to different varietal preferences exhibited by adults (high dry matter content) and young children (low dry matter content). This stimulated the retention and greater use of the low-dry-matter variety Pumpkin in all phases of the work, and high acceptability of enriched weaning foods by children.

Numerous elements of this intervention are potentially sustainable:

- » The intervention does not require large amounts of land, nor will it require most western Kenyan farmers to switch all of their current land under white-fleshed sweet potatoes to orange-fleshed varieties. Typically families in Ndhiwa areas have one to two sweet potato plots. The average size of the largest plot varies from 0.03 to 0.05 hectares. To meet the recommended vitamin A intake needs of an average family of 5.7 members, only 0.033 hectares of land under orange-fleshed sweet potato is required. Moreover, only 44 square meters of land planted with orange-fleshed sweet potato would supply the daily recommended amount of vitamin A for a one- to six-year-old child. (Estimates are based on average yields of 10 tons/hectare, assuming a 10% postharvest loss, 26% weight loss due to peeling, and an average β-carotene content after cooking of 455 μg RE/100 g.
- » The widespread dissemination of vines to grow orange-fleshed sweet potato roots occurred quickly, even during the time that the study was being conducted. A tradition exists in western Kenya whereby farmers pass vine cuttings to other farmers free of charge, a practice that could help to ensure rapid and ongoing dissemination. Furthermore, when one farmer loses planting material of a particular variety due to drought, she can readily obtain it from neighboring areas.
- » On-farm trial data showed that the new sweet potato varieties survive droughts well (once established) and have yields higher than the traditional white varieties, factors that are important for sustained cultivation. The only weak point is the apparent greater susceptibility of finer vines (characteristic of Japonese and Pumpkin, but not Kakamega) to dry out if exposed to long periods of drought. One strategy adopted by many women is to maintain easily supervised kitchen plots to guarantee sufficient planting material.
- » The activities that promoted vitamin A consumption strengthened the ability of women to translate production of a crop largely under their control into improved nutritional intake among their young children. This helps enable women to meet their dual responsibilities as producers and caregivers in an efficient and effective manner, thus increasing the likelihood that the study participants will continue to apply the lessons they learned through this project.

Using the results from the β-carotene analysis done in this study, other recent findings regarding the bioefficacy of β-carotene from sweet potato* and other plant sources [3, 21], and the recent retinol activity equivalent (RAE) factor of 12:1 for the conversion of β-carotene to retinol [22], recommendations concerning consumption of orange-fleshed sweet potato for young children can be made. Only orange-fleshed sweet potato varieties with high retinol equivalence should be promoted (e.g., Pumpkin, Japonese, and W-220 in table 7), not yellow-fleshed varieties, whose β-carotene content after boiling is inadequate. To take the Pumpkin variety as an example, two one-half cup servings alone fed each day to children one to six years of age would meet their recommended dietary allowance (RDA) of vitamin A. Moreover, one cup of mashed sweet potato would meet approximately 27% of the daily energy needs of an average size one- to two-year-old child. Adding fat to sweet potato-based weaning foods is also recommended, to increase the energy density of the food and enhance absorption. In addition, programs should include deworming campaigns where parasitic infections are prevalent to enhance vitamin A absorption.**

It is likely that food-based strategies using the promotion of orange-fleshed sweet potatoes as an entry point for improved consumption behaviors, such as the one described in this report, will prove to be an effective and sustainable way to improve the vitamin A status of young children and their families around the world. Future research needs to include biochemical outcome indicators and refine the methodology for achieving changes in feeding practices.

## Recommendations

The results of this study suggest several key recommendations for program planners and policy makers.

* In this study conducted by Jalal et al. [3] in Indonesia, children three to six years of age who were marginally deficient in vitamin A were supplemented with 750 RE of β-carotene (two snacks plus one main meal) six days a week for three weeks. Sweet potato provided 80% of the β-carotene consumed. The supplementation resulted in a significant increase of 0.20 to 0.24 μmol/L in serum retinol concentration.

** The Indonesian study results showed that the clearest rise in serum retinol occurred when meals contained additional β-carotene sources (mostly sweet potato) or added fat, and when the children were dewormed.

TABLE 7. Amount of sweet potato required (number of cooked 1/2-cup servings and number of raw, medium-sized roots) to meet daily vitamin A requirements of children 12 to 23 months of age (400 μg RE/day) and percentage of average energy needs met

| Using fresh roots containing × μg RE/100 g[a] (example of sweet potato variety) | Amount of sweet potato required based on μg RAE (12:1 conversion factor)[b] | | | |
|---|---|---|---|---|
| | Total amount cooked daily (g)[c] | No. of 250-g roots (raw)[d] | No. of 1/2-cup servings (cooked and mashed)[e] | % average energy needs[f] |
| 1000 (W-220) | 123 | 0.6 | 1.0 | 13.9 |
| 700 (Japonese) | 176 | 0.9 | 1.4 | 19.8 |
| 500 (Pumpkin) | 246 | 1.2 | 2.0 | 27.7 |
| 250 (Kakemega 4) | 491 | 2.5 | 4.1 | 55.3 |

*a.* Micrograms of RE based on a 6:1 conversion rate of β-carotene to retinol [20] to be consistent with figures published earlier [9].
*b.* Micrograms of retinol activity equivalents (μg RAE) based on relative availability of mixed vegetables to that of β-carotene in oil, using the recent 12:1 conversion rate of β-carotene to retinol [22].
*c.* Accounting for average losses of 35% of total carotenoid content due to boiling.
*d.* Accounting for average weight loss of 26% when sweet potatoes are peeled.
*e.* One-half cup can hold 120 g of cooked and mashed sweet potato.
*f.* Energy density of sweet potato is 84 kcal/100 g; average caloric needs of a 12- to 23-month-old child of average size are assumed to be 746 kcal/day.

#### Expand efforts to improve nutritional status through dietary change in other regions

This study indicates that deficiencies of vitamin A can be reduced within one year through an agricultural food-based intervention. Dietary change interventions could be sustained by district-level Ministry of Agriculture offices in areas where sweet potatoes are grown, and are recommended in areas where vitamin A deficiency is prevalent. Furthermore, sweet potatoes are consumed throughout eastern and southern Africa, where a number of different varieties are available. It is therefore important to promote the production and consumption of appropriate varieties of food crops in parts of these regions that have similar levels of vitamin A deficiency.

#### Strengthen women's ability to carry out dietary change in their households

Because women are primarily responsible for the family diet and for the care of children, considering ways to strengthen their ability to meet these responsibilities is recommended. The ability of women to meet the nutritional needs of their families was strengthened by focusing on a crop typically under their control. The introduction of a new variety that was rich in vitamin A and the provision of an integrated package of activities and support enhanced nutritional outcomes. The investment in women translated into nutritional benefits for their children. Replication of the same design and adoption process in other regions would probably yield similar nutritional benefits in agriculture-based economies that have high rates of subclinical vitamin A deficiency.

#### Train appropriate extension workers in basic health and nutrition messages

Although home economics extension workers receive nutritional training, they tend to be fewer in number and have less mobility in getting out to the field than agricultural extension agents. At the same time, these agents receive little training in nutrition. In addition, while some health agents may work at the community level, they tend to focus their efforts on curative services or prevention activities, such as feeding practices or growth-monitoring and promotion, and less on food production. Thus, to enhance sustainability, nutrition-focused components need to be included in the training and work agendas of both agricultural and health extension agents.

#### Involve everyone when promoting the production and consumption of vitamin A–rich sweet potatoes

Women's group members suggested that including their husbands and other community members in project activities could enhance adoption of the new sweet potato varieties. Increasing men's knowledge of the important nutritional contributions that these food crops make to the health of their families, and particularly their children, is expected to be beneficial. Elementary school-aged students, particularly girls, could also be key target audiences, given the influence that girls will have on their future families' health. Greater emphasis needs to be given in the future to more extensive use of social-marketing techniques for encouraging widespread behavioral change and increasing market demand for orange-fleshed roots.

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# Marketing of red palm oil as a food source of vitamin A in Burkina Faso: A pilot project involving women's groups

Hélène Delisle, Noël Zagré, and Virginie Ouedraogo

## Abstract

*Consumption of red palm oil for its provitamin A activity could extend to nonproducing areas of Africa. To assess the impact of red palm oil introduction, vitamin A status was measured in a random sample of mother-child pairs in the pilot areas. This paper describes the marketing approach, the evaluation design, and results after one year. Red palm oil purchased in southern Burkina Faso is retailed in the north-central pilot area by women's groups. At onset, serum retinol was low in 66% of children and 43% of mothers. After one year, 94% of mothers reported liking red palm oil, 71% had purchased it, and 32% had consumed some in the last week. The rates of risk of inadequate vitamin A intake declined by one-third. Prior to scaling-up, the main challenges ahead are positioning red palm oil as a food supplement rather than a cooking oil, and determining whether the increased demand can be met by local production without undue pressure on prices.*

## Introduction

Vitamin A deficiency is a major nutritional problem in most of Sahelian Africa [1, 2], owing primarily to the scarcity of vitamin A–containing foods at least for part of the year. Furthermore, the bioavailability of provitamin A carotenoids from available food sources may be limited. In Niger, for instance, we found that dark-green leafy vegetables provided up to 86% of the dietary vitamin A of preschool-age children [3]. According to recent findings, green-leaf carotenoids are much less bioavailable than previously assumed, and their conversion ratio to retinol may be as low as 26:1 [4], depending in part on the method of preparation. The ratios are higher in other fruits and vegetables (approximately 12:1), although still lower than the conventional 6:1 for β-carotene irrespective of the source. Although supplementation with high-dosage vitamin A capsules is an effective control measure in the short term, food-based approaches are needed for long-term prevention of vitamin A deficiency [5]. Red palm oil is produced in parts of Africa. It is the richest plant source of vitamin A activity, and the carotenoids of red palm oil are of high bioavailability, with a reported bioconversion ratio of 6:1 [4]. Many trials have shown the efficacy of red palm oil as a vitamin A source.

In India, for instance, red palm oil incorporated in a sweet improved the vitamin A status of schoolchildren, and a daily intake of 8 g proved as effective as a single high-dosage capsule, after three months [6, 7]. Red palm oil-fortified cassava flour was also shown to improve the vitamin A status of preschoolers in Tanzania [8], and red palm oil-fortified biscuits were successfully introduced among schoolchildren in South Africa [9]. Red palm oil has been reported to be effective in sustaining or improving the vitamin A status of pregnant women in Tanzania [10] and of lactating women in Honduras [11]. Red palm oil is usually consumed only in zones of production, but it can be introduced effectively in other areas as well, as the above studies suggest.

In India, Narasinga Rao [12] showed that a cooking oil blend containing 6% to 12% red palm oil was well accepted by women. However, acceptability goes beyond taste trials, and as underlined in a recent review [13], there are still information gaps on the feasibility of dietary approaches to improve vitamin A nutrition. Furthermore, red palm oil will be effective only if it is demonstrated that the population to which it is introduced is willing to purchase and use it on a regular basis. This was the thrust of a pilot project in Burkina Faso, where red palm oil is produced and consumed only in the southern part of the country. This provided a unique opportunity to

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introduce an indigenous provitamin A–rich product into nonconsuming communities in the northern section of the country where dietary vitamin A intakes are low.

The objectives of a 30-month pilot project were to assess the feasibility of introducing red palm oil in nonconsuming areas, and its effectiveness. Feasibility refers to the acceptability of red palm oil as a food supplement for women and preschool-age children, in terms of taste and price, and supplying it from the red palm oil production area of Burkina Faso. To assess effectiveness, the impact of red palm oil introduction on vitamin A status was measured in a random sample of mother-child pairs in the pilot areas. This paper describes the marketing approach, evaluation design, and results after one year.

## Methods

Project activities pertain to the promotion of red palm oil in the selected area of Burkina Faso, collection of red palm oil in the production zone of the country and its commercial distribution in the pilot area, and monitoring and evaluation.

### Promotion of red palm oil in the pilot area

The pilot area consisted of 10 villages and one city district in the Kaya region of Sanmatenga Province, east-central Burkina Faso. The primary target population was around 10,000 women of childbearing age and children under five years of age. In addition to size, the criteria for selecting the pilot area included evidence of a vitamin A deficiency problem, but no structural food shortage, because in such a case food security would have to be the priority issue; home economists already active in the zone to take on project activities; and accessibility of the area in all seasons to allow for project supervision and monitoring. The pilot zone corresponded to a health district, which facilitated collaboration with the health sector, even though the project was housed in the agriculture service.

Social marketing [14] was the main approach for promoting red palm oil, using both the media and person-to-person communication. The formative phase included focus groups with home economists from the area and with village women in order to identify predisposing, enabling, and facilitating factors to adopting red palm oil, according to the PRECEDE (predisposing, reinforcing, and enabling constructs in educational/ environmental diagnosis and evaluation) model of educational diagnosis [15]. A baseline study was carried out in a population subsample, and the findings on vitamin A–related knowledge, attitudes, and practices (KAP) were incorporated into the social-marketing plan. Eleven home economists (animatrices) and a few other extension workers already involved in the pilot area were given a one-week training workshop on social-marketing techniques as applied to the project prior to the initiation of red palm oil promotional activities. Educational messages were developed and tested with women of the pilot area before being disseminated. An additional three days of training was given after six months of field activities.

Red palm oil was promoted as an individual food supplement for vitamin A rather than as a cooking or seasoning oil. The rationale for this market positioning is that red palm oil should not compete with, nor be a substitute for, groundnut oil and shea butter, which are traditional and commonly used fats in the pilot area but that are devoid of vitamin A activity. Red palm oil is more expensive than these other sources of fat, but since only small amounts are required owing to its high concentration of provitamin A, it should not be regarded as expensive. Furthermore, we wished to avoid red palm oil being "burned" when used in cooking, which destroys most of the vitamin A activity [16].

Following the official red palm oil launch day with formal speeches, free sample distribution, and media coverage, several promotional activities have been ongoing since August 1999. These include group talks using posters and flip-charts, food demonstrations and tasting of family and complementary foods with red palm oil added just before eating, radio spots, short sketches and a show program, intervillage contests, and soon to come, theatre plays using older schoolchildren. Examples of radio spots that were aired in the pilot area many times a day for a period of four months are "Palm oil from Burkina, red for vitamin A" and "It is simple, one spoonful of red palm oil for your baby, two for you." Home economists periodically combined their promotional activities with those of health workers, including growth-monitoring at the village level. They recently took part in the national immunization days, disseminating their red palm oil messages along with the distribution of vitamin A capsules and polio vaccinations in pilot project sites. The key messages are that red palm oil is red because it contains vitamin A, like the capsules; it is always there for use by women and all young children; it comes from Burkina Faso; and its price is reasonable, as only small amounts are needed.

### Collection and commercial retailing of red palm oil

The feasibility study suggested that local red palm oil production could meet the new demand created by the project, and during this first project phase, there was no special effort to increase red palm oil production or to support and strengthen women's groups involved in this activity. Red palm oil was collected by the project in two villages in the southwestern part of the country, where the oil is traditionally produced by women. It was purchased at a fixed price from women who use a process compatible with good quality red palm oil. It has not been possible, contrary to initial plans, to subcontract to a single women's group for collection and transportation of the oil to the city of Kaya, the central point of the pilot area.

The oil is stored in Kaya and dispatched to women who sell it in the pilot zones. Retailers and members of village committees were created to manage and supervise sales after being trained in red palm oil handling, hygiene, and sales management. Village committee members were selected by the community and included both men and women. Committees are responsible for paying back the cost of oil purchased on credit from the project and for returning to retailers their profit margin (about 8%). The oil is retailed in quantities varying from 15 ml to 1 L in nontransparent glass or plastic containers for better retention of vitamin A activity. The most common quantity is the 125-cc plastic bottle. The price is US$0.013 per day (for 10 ml, the average advocated supplement), although there are small economies of scale. Currently the retail price is subsidized, as it only partly covers the transportation and marketing costs.

A sampling and analysis protocol was developed to assess and control the quality of the traditional red palm oil retailed in the project. Samples were collected at production sites and after storage for up to two months or at retail sites. The oil appears to be of good quality, according to physical, chemical, and bacteriological tests, for at least two months after production. The moisture content is low (0.4%), the foreign material content is also very low, and the acidity and peroxide indices are well below the respective quality cutoff points of 7% and 5%, as used in other red palm oil-consuming areas [17]. Aflatoxin was not detected, and total bacteria and coliform counts were low, although some human contamination may occur at the retail level, as coliforms were detected in one site after four weeks of handling the oil. This underlines the importance of regular monitoring of hygiene conditions. Samples that have been stored or offered at retail for various lengths of time are being analyzed for vitamin A activity by high-performance liquid chromatography (HPLC) in a laboratory of the Faculty of Sciences of the University of Burkina Faso. This HPLC unit is being strengthened by the project, with the aim of providing a self-sustaining laboratory service for vitamin A analyses of foods and biological samples to projects and programs at the subregional level. According to preliminary analyses of only a few red palm oil samples after three months of storage, the vitamin A activity was approximately 100 μg RE/g, which appears slightly lower than published data [18]. Further analyses will clarify baseline levels and variance, as well as retention rate according to storage time and conditions.

### Evaluation design

To evaluate the impact of the project, the baseline study was repeated after 12 and 24 months with the same sample of mother-child pairs. Seasonality effects were controlled by conducting all three surveys at the same time of year. The principal assessment variables are knowledge, attitudes, and practices (KAP) of mothers, intake of vitamin A–containing foods by mothers and children, and their serum retinol concentrations. The sample of 210 mother-child pairs was randomly selected from the target population in the only urban district of the pilot area and in 6 out of the 10 villages with a population of 1,000 or more. The sample size was determined based on vitamin A intake estimates, since this variable calls for a larger sample than serum retinol to demonstrate a significant change, owing to a higher variance. Mean vitamin A intake was estimated at 300 μg RE/day with a 50% variation, based on prior studies among preschoolers in Niger [19]. For an $\alpha$ error of 0.05 and a statistical power of 0.90, the required sample size for a mean dietary increment of 100 μg RE to be significant was 200 subjects. The sample was increased to 210 to give a margin of safety. In each of the seven sampling sites, 30 mother-child pairs were randomly selected among households having a child in the 12- to 36 month-range at the onset of the study, based on household census and personal verification. Mothers gave their informed consent prior to joining the study.

The baseline and two subsequent surveys included the same variables, except that only two serum samples were collected from mothers and children for vitamin A status assessment: one at baseline and one 24 months later. Maternal interviews were conducted by one of the researchers assisted by trained women enumerators. The KAP component of the study focused on mothers' knowledge of night-blindness, its causes, treatment, and prevention, and their knowledge, like or dislike, and use of red palm oil. They were also questioned on whether they or their children had taken vitamin A capsules. The vitamin A food-frequency questionnaire was administered to mothers, who were asked to recall their consumption and that of the target child.

A list of locally consumed vitamin A sources, with average serving sizes for children and mothers expressed in local measures, was constructed in the course of preliminary work for the study in three intervention sites. Sets of cups, bowls, and spoons were used to assist maternal recall. For vegetable sources of vitamin A, the recall went back for one week, whereas in the case of animal foods, the mothers were asked about the frequency and size of servings over the previous month, since such foods are infrequently eaten.

This approach was deemed desirable in our study on the validation of the food-frequency questionnaire in Niger, which showed that consumption of animal food was incompletely captured in the weekly recall [19].

Blood specimens were collected in vacutainer tubes, allowed to clot, and centrifuged. The supernatant sera were kept in ice until they were transferred within 24 hours to a freezer and kept at –18°C until analysis. Serum retinol was measured by HPLC according to standard procedures at the laboratory of the Faculty of Sciences, University of Ouagadougou.

A cross-sectional study among lactating women is also being conducted in order to assess the rate of red palm oil adoption after 18 months in this target group, and to examine the relationship of red palm oil intake to maternal serum and milk retinol and carotenoids. The study involves approximately 100 mothers breast-feeding children aged one to nine months.

## Project outputs and results after one year

### Mothers' knowledge, attitudes, and practices

More than 2,000 persons took part in talks, food demonstrations, and tasting of red palm oil over the first 12 months of project activities. The one-hour radio show on the project, which was taped in one of the intervention villages, was replayed four times over a two-month period in the pilot area. Over a four-month period, two radio spots and one sketch on red palm oil were aired several times a day. Not only women, but also men, were reached by media and community-level social-marketing activities. Maternal awareness of red palm oil and project activities, as well as vitamin A–related knowledge, improved after one year of project operation. As seen in figure 1, all respondent mothers knew red palm oil by then, compared with 75% at the onset of the project one year earlier. The taste is well liked, with acceptance reaching 95%. All women knew about night-blindness by the end of one year, and it is noteworthy that only 2 cases were reported, compared with 35 the previous year. A low 27% identified a faulty diet as a cause of night-blindness, but only 13% had done so in the first survey. *Sabga*, an undefined illness condition, remains the most frequent cause given, with more than 40% of respondents stating it in both surveys. In spite of educational endeavors, 21% still could not mention any correct means of prevention of night-blindness, although this percentage was down from 74% one year before.

As table 1 shows, 63% of respondent mothers were aware of red palm oil promotional activities. Talks or food demonstrations were mentioned more often than radio spots or programs, which suggests that women may not be frequent radio listeners. Other indices of red palm oil awareness are that 96% knew who sold the oil in their community and that 90% reportedly talked about the oil around them. It is also seen that 72% reported purchasing red palm oil at least once since the first survey, and 32% of mothers and children had consumed some in the last week. The average portion size was 12.5 g for children and 26 g for women who reported using red palm oil during the last week. However, these figures may overestimate the impact, since women belonging to the survey sample knew ahead of time when they would be interviewed

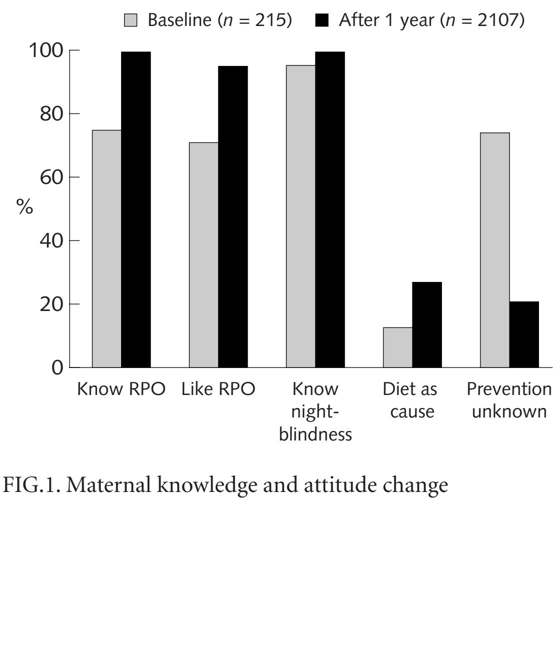


FIG.1. Maternal knowledge and attitude change

TABLE 1. Response of mothers after 12 months of promotion of red palm oil (RPO)

| Attitudes and practices | % of mothers ($N = 207$) |
|---|---|
| Aware of promotional activities | 63.1 |
| Talks | 92.3 |
| Food demonstrations | 65.4 |
| Radio | 31.5 |
| Know who retails RPO in village | 95.6 |
| Talked about RPO | 90.1 |
| Purchased RPO at least once | 71.5 |
| Would like to buy more…but: | 98.7 |
| Too expensive | 69.5 |
| Cannot find it | 16.9 |
| Do not like it | 13.6 |
| How RPO used | |
| Added to child's individual dish | 20.8 |
| Added to own individual dish | 11.0 |
| Added to children's common bowl | 71.2 |
| Added to household common bowl | 81.2 |
| Used in cooking | 7.1 |
| Consumed RPO during last week | |
| Average portion size: 26 g | 31.5 |
| Gave RPO to child during last week | |
| Average portion size: 12.5 g | 31.6 |

again. In the first 12 months, the total sales volume of red palm oil amounted to 1,210 L, which represents approximately 120 cc per targeted individual (mothers and under-five children), that is, roughly 7% of the target of 5 cc per person per day. However, the project is only one year old, and the adoption rate is expected to keep growing. Reported constraints to purchases were the high price of red palm oil (69%) and problems of supply (17%), rather than dislike of the taste (14%). The project recommends that red palm oil be added to individual plates of children and mothers prior to eating, rather than to the common household bowl, or else used for cooking. As seen in table 1, 71% of mothers added red palm oil to the children's common bowl, but only a small proportion (11%) added it to their own individual plates. It seems that adding it to the common household bowl is the most common practice.

### Vitamin A intake and status of mothers and children

The mean and median vitamin A intakes of mothers and children at baseline and 12 months later are given in table 2. Nearly all vitamin A is in the provitamin form and even more so for mothers, who eat less liver than their children. Mother's total vitamin A intake doubled between baseline and the second survey, and it more than trebled in children. By then red palm oil provided 36% and 46% of total vitamin A for children and mothers, respectively, in survey 2. Liver and egg consumption also increased between the two surveys.

At baseline, 83% of the mothers and 88% of the children were at high risk of inadequate vitamin A intake;* the respective rates were 38% and 49% one year later. These figures are based on vitamin A intakes computed by using the conventional conversion factors of 6:1 in the case of β-carotene and 12:1 for other carotenoids. Based on several studies, de Pee et al. [4] proposed differential conversion factors, with 26:1 for poorly utilized green-leaf carotenoids, 12:1 for other vegetables and fruits, and 6:1 for red palm oil. When these figures are used, a different picture emerges, with still lower vitamin A intakes at baseline and a more dramatic improvement with consumption of red palm oil. As seen in figure 2, the mean maternal vitamin A intake went from 133 μg RE at baseline to 568 RE one year later, whereas in children it was only 64 RE at baseline and reached 347 μg RE one year later. With these conversion factors, nearly all mothers (98%) and children (99%) were at a high risk for inadequate vitamin A intake at baseline, compared with 62% of children and 63% of mothers one year later. The change was due primarily to consumption of red palm oil, which increased mean vitamin A intakes fivefold. However, skewing is high owing to red palm oil, and indeed, in survey 2 the median vitamin A intakes were roughly half the mean intakes.

Vitamin A intake data are best interpreted together with vitamin A status data. Preliminary results of baseline serum retinol concentrations are available, but additional data will come only after the final survey, since blood samples were not collected at midterm.

* Less than 62.5% of the safe level of intake, which is roughly the mean requirement, since the safe level of intake is set 2 SD above mean requirement, with a 20% coefficient of variation.

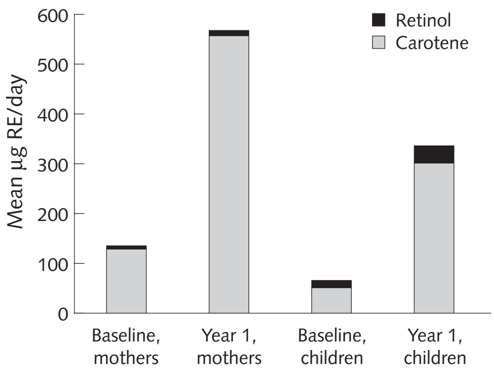


FIG.2. Vitamin A intakes using revised conversion factors [4]

TABLE 2. Mean ± SD (median) vitamin A intake of mothers and children at baseline and 12 months later

| | Baseline($T_0$) | | 1 year ($T_{0+12m}$) | |
|---|---|---|---|---|
| Intake | Mothers ($N = 212$) | Children ($N = 210$) | Mothers ($N = 203$) | Children ($N = 196$) |
| Total vitamin A (μg RE/day) | 302 ± 235 (252) | 138 ± 106 (111) | 801 ± 913 (426) | 510 ± 493 (326) |
| Retinol (μg RE/day)[a] | 6 ± 22 (0) | 13 ± 26 (0) | 11 ± 23 (0) | 46 ± 79 (19) |
| Provitamin A (μg RE/day) | 295 ± 231 (245) | 125 ± 103 (101) | 790 ± 910 (408) | 465 ± 463 (299) |
| % below 62.5% of safe intake level | 82.9 | 87.6 | 49.3 | 37.7 |

*a.* Conventional β-carotene:retinol conversion factor of 6:1.

The mean serum retinol levels at baseline were 0.75 ± 0.55 μmol/dl in children and 0.90 ± 0.49 μmol/dl in mothers (partial results only). Two-thirds of children and 43% of mothers had low serum retinol concentrations (<0.7 μmol/dl). Although the findings are only preliminary, they confirm that the vitamin A problem is serious in the area. It should be noted that the blood samples were collected seven months after vitamin A capsule distribution coupled with the national polio immunization campaign, with a coverage rate above 90% among under-five children. This is further evidence of the dire need for a mix of food-based approaches for the sustainable prevention of vitamin A malnutrition in Sahelian zones such as that covered in the pilot project.

## Conclusions and challenges ahead

The progress of the pilot project after one year of operation looks promising as regards the feasibility and impact of red palm oil introduction in nonconsuming areas of Burkina Faso. Red palm oil was deemed particularly useful because of the high bioavailability of its provitamin A carotenoids and because it is produced in Burkina Faso. There still are challenges to meet and questions to answer. For instance, the project has not been totally successful in positioning red palm oil as an individual food supplement for mothers and children, rather than as seasoning oil for the whole family. The attempt will be pursued, since it is felt that if red palm oil is perceived as an alternative for other fats and oils, it will tend to be used as a substitute only when the price is lower, which is unlikely once its selling price is no longer subsidized. Using red palm oil for the whole family increases its cost owing to the amount required, and it dilutes the benefits because some family members may not need a vitamin A supplement.

The KAP study conducted 12 months after baseline showed some improvement in relevant knowledge of the mothers, but it also emphasized the need for continued educational efforts. For instance, only a small proportion of mothers were able to state that certain foods, or even a better diet, could protect from night-blindness. Promotion of red palm oil using social-marketing strategies has raised awareness of the product, and close to one-third of sampled mothers had consumed the oil and given some to the target child during the previous week. This rate has to keep rising to reach the minimum objective of 50% regular consumption of red palm oil, at least weekly, among women and under-five year old children in another year. Other dietary means of improving vitamin A intake should also be defined with women themselves and implemented, as initially planned; red palm oil cannot be the sole solution. The ongoing studies on red palm oil quality according to storage time may indicate a limited shelf life after production for optimal taste and vitamin A activity. Efforts at combining red palm oil promotion by home economists with health-sector activities have been fruitful, in particular, combining village-level communication about the oil with distribution of vitamin A capsules during the polio vaccination campaigns. Further integration with routine health-care activities such as child growth-monitoring and promotion needs to be pursued.

Scaling-up is already foreseen in a second project phase, since this is all too often the stumbling block of dietary diversification strategies for micronutrients. Introduction of red palm oil into school lunch programs, expansion of marketing and distribution of the oil to the whole Sahelian area of the country with routine selling in local markets by formal retailers, and technical and marketing support for groups of women who process the oil are among the planned strategies for expansion. The extent of scaling-up will depend upon the final results of the pilot phase, as well as upon the conclusions of an upcoming study on red palm oil production and markets. A key issue is whether the production potential is adequate to meet the increased demand for the oil without undue price changes.

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# Dietary approaches to the prevention of vitamin A deficiency: Indian experience with red palm oil as a source of vitamin A

B. S. Narasinga Rao

## Abstract

*In an effort to continue to reduce vitamin A deficiency in India, studies have been conducted using red palm oil. The bioavailability of β-carotene in red palm oil is higher that than of green and yellow vegetables, with an absorption rate of nearly 90%. Studies have shown that red palm oil is safe and acceptable. Refined red palm oil (Carotino) can be mixed with other refined edible oils without affecting their taste. It does add a yellow color, for which consumer education is needed. Because of stability problems, the final product selected for feeding would need to contain 7% to 10% of the Carotino, depending on the form used. Further studies are being planned to evaluate the effect of Carotino-containing supplements on growth and vitamin A status of children. A major limitation to producing supplementary foods containing red palm oil is the small amount of red palm oil produced in India at this time; most of it has to be imported from Malaysia.*

## Introduction

Vitamin A deficiency is a major nutrition problem in India among preschool children. Vitamin A deficiency, its prevalence, clinical manifestations, and health and functional consequences, has been studied in India since the 1930s [1]. One of the serious consequences of severe vitamin A deficiency is nutritional blindness among young children, which was recognized fairly early during studies on vitamin A deficiency in the country. One of the main causes of widespread vitamin A deficiency among children in India is the low intake of carotene-rich foods. The average daily intake of carotene by the preschool child population of low-income groups is only about 20% of the recommended dietary allowance (RDA) (table 1); this is particularly so in rural areas [2]. Although India is a major producer of fruits and vegetables [3], per capita availability of β-carotene from all these sources falls short of the recommended intakes, being only about half of the RDA (table 2).

Although the prevalence of severe forms of vitamin A deficiency was quite high until the beginning of the 1980s, it has decreased markedly in the past 10 to 15 years. The extensive Indian experience with the use of red palm oil as a source of provitamin A that began in 1935 has been reviewed previously [4]. This paper presents further experience with red palm oil use and some more recent data based on the availability of a more refined red palm oil (Carotino) produced by molecular distillation [5].

TABLE 1. Dietary nutrient deficiencies among preschool children of the low-income group

| Nutrient | RDA | Mean daily intake | % of RDA |
|---|---|---|---|
| Macronutrients | | | |
| Energy (kcal) | 1,240 | 750 | 60 |
| Protein (g) | 22 | 22 | 100 |
| Fat (g) | 25 | 5.3 | 21 |
| Calcium (mg) | 400 | 193 | 48 |
| Micronutrients | | | |
| Iron (mg) | 12 | 5.9 | 49 |
| Retinol (μg) | 400 | 61 | 15 |
| Thiamine (mg/1000 kcal) | 0.5 | 0.5 | 100 |
| Riboflavin (mg/1000 kcal) | 0.6 | 0.3 | 50 |
| Nicotinic acid (mg/1000 kcal) | 6.6 | 9.6 | 145 |
| Ascorbic acid (mg) | 40 | 4.4 | 11 |
| Folic acid (μg) | 40 | 14.6 | 37 |
| Vitamin E (mg) | 5.0 | 7.5 | 150 |
| Pyridoxine (mg) | 2.0 | ? | 150 |

Source: Based on a National Nutrition Monitoring Board (NNMB) survey.

The author is the former Director of the National Institute of Nutrition in Hyderabad, India.

Mention of the names of firms and commercial products does not imply endorsement by the United Nations University.

TABLE 2. Estimated annual production of fruits and vegetables and per capita availability of carotenes (1991)

| Source | Production (million tons/yr) | Carotene availability[a] (μg/day/ capita) | % contribution |
|---|---|---|---|
| Fruits | | | |
| Mango | 9.2 | 455 | 38.0 |
| Orange | 1.35 | 32 | 2.0 |
| Papaya | 0.35 | 6 | 0.4 |
| Total | 10.90 | 492 | 40.4 |
| Vegetables | | | |
| Roots and tubers | 23.4 | 12 | 1.0 |
| Green leafy vegetables | 6.8 | 623 | 51.9 |
| Tomato | 2.0 | 17 | 1.4 |
| Other vegetables | 11.9 | 18 | 1.6 |
| Total | 43.9 | 670 | 55.9 |
| All sources | 54.8 | 1,162 | 96.3 |
| RDA | | 2,290 | |

*a.* Availability at retail level after taking into account postharvest losses.

## Red palm oil as a source of provitamin A

Taking into consideration the bioavailability of β-carotene from plant sources such as carrots, the Food and Agriculture Organization/World Health Organization (FAO/WHO)[6] proposed that the retinol equivalent of 1 μg of β-carotene is 0.16 μg. On the other hand, the Expert Group of the Indian Council of Medical Research (ICMR) on RDA [7] for Indians has recommended that the retinol equivalent of 1 μg of carotene derived from carotene-rich foods (green leafy vegetables) consumed in India be 0.25 μg.

Red palm oil contains a mixture of carotenes, but the bioavailability of its β-carotene is higher than that from green and yellow vegetables. It would appear from studies carried out in India on the serum retinol response to administration of red palm oil that the absorption of β-carotene from the oil is nearly 90% and the retinol equivalent is 0.3 to 0.35 μg. One may thus assume that the retinol equivalent of 1 μg of β-carotene in red palm oil is 0.3 μg.

## Blending of crude red palm oil into edible oils

The stability of carotene in edible oils blended with crude red palm oil (CRPO) was also studied at the Harcourt Butler Technological Institute, Cawnpur, where the feasibility of incorporation of crude red palm oil in edible oils and hydrogenated vegetable oils (vanaspati) was also explored [8]. The refined red palm oil produced by molecular distillation (Carotino) that is now available can be easily blended with common edible oils at levels of 10% to 15% without adversely affecting the organoleptic properties of foods prepared with such blends. However, the population may need to be educated and motivated to accept the light golden color of these blends.

## Recommendations of the National Nutrition Advisory Body in India concerning the use of red palm oil for fighting vitamin A deficiency during 1937–1940

The interest in India in the use of red palm oil to combat vitamin A deficiency is not of recent origin but began nearly seven decades ago. There was, however, no action on the production and use of red palm oil in combating vitamin A deficiency as a follow-up to the research done at the National Institute of Nutrition or the recommendations of National Advisory Committee of the National Nutrition Advisory Body. However, oil palm cultivation was started on a small scale at Palode, Kerala, in South India, during the early 1970s [9].

The author has previously reported [4] on a long series of studies in India initiated and conducted by the National Institute of Nutrition demonstrating the value of red palm oil preparations then available for child feeding [10–16]. After the more refined red palm oil (Carotino) became available in 1995, a few more studies were conducted in the laboratory and the community to assess its acceptability and the impact of the oil on the vitamin A status of children.

## Nutritional and safety evaluation of crude red palm oil

A nutritional evaluation of deodorized and deacidified red palm oil in rats [10] and multigenerational toxicological studies in rats [11] indicated that feeding this product had no adverse effect on growth, reproductive performance, or histopathological abnormalities. Similarly, foods fried in repeatedly heated crude palm oil had no mutagenicity when tested by the Ames Test [12].

## Stability of carotene in locally deacidified and deodorized red palm oil during cooking

The effects of different cooking methods on the stability of the total and β-carotene content of red palm oil have been reported previously [4, 13], indicating a loss of 10% to 30% of the carotene in the cooked foods. Sarojini also studied the stability of carotenes and tocopherols in biscuits, sweetmeats, and pickles prepared with red palm oil or its blends; carotene loss varied from 20% to 50% [14]. Some of these studies on cooking losses were repeated with refined red palm oil [Manorama R, personal communication, 2000], with similar results. Red palm oil can be used in cooking operations involving only short-time heating, and wet cooking can retain about 70% of carotenes present in the original oil.

## Acceptability trials with foods cooked in red palm oil

De reported in 1937 [8] that foods cooked in unprocessed crude red palm oil were totally unacceptable. He found that foods cooked in other oils containing 6% to 12% CRPO were acceptable. However, acceptability trials with foods cooked in partially processed red palm oil, i.e., deacidified and deodorized red palm oil (DDCRPO) indicated that they were moderately acceptable. Foods prepared with a blend of deacidified and deodorized red palm oil with other traditional oils, such as peanut or safflower oil, at the ratio of 30:70 were fully acceptable. However, foods cooked in other blends with proportions of crude red palm oil in this range were much less acceptable. Such limitations in the acceptability of foods containing deacidified and deodorized red palm oil have also been reported in the subsequent community studies [15, 16].

These limitations of acceptability do not apply to foods prepared with the recently commercially refined red palm oil, Carotino. Common dishes prepared with this oil are entirely acceptable and indistinguishable from foods prepared using traditional oils such as groundnut or refined palm olein. Red palm oil blends well with Indian curries, pickles, and other food preparations that are mostly colored yellow, red, or brown. By using Carotino, which is deep red in color, one can dispense with turmeric or saffron used to impart a pleasant yellow color to Indian dishes such as yellow rice, sweet halwa made from semolina, and pickles.

## Enriching edible oils with β-carotene using refined red palm oil

Carotino, the refined red palm oil that is currently available from Malaysia, can be blended with other commonly used refined edible oils to the extent of 10% to 15% to enrich these oils with β-carotene as a source of vitamin A activity without affecting the odor or taste of the oils. Such blended oils will provide about 50 to 75 µg of β-carotene per gram of oil. At the current recommended intake of edible oils of 30 g/day (10% of energy), the deficit in the per capita intake of vitamin A (1200 µg carotene/day) can be met easily, and the full vitamin A needs of the Indian population can be met. However, the consumer will need to be educated through nutritional education and social marketing on the nutritional advantages of such edible oils blended with red palm oil and persuaded to accept its slightly yellow color. There is another requirement that needs to be fulfilled before such blending can become a successful commercial venture, that is, the cost of imported Carotino, which now is higher than that of other oils. The solution would be to manufacture it in India. I have recommended at different forums that the limited quantities (about 10,000 tons) of palm oil produced in India be used to produce refined red palm oil to be used in feeding trials in the ICDS and for fortifying edible oils to enrich them with β-carotene to provide additional vitamin A in the diets of the Indian population.

The results of studies summarized previously [4] indicate that the serum retinol levels in children fed 4 g of red palm oil at the end of three months were similar to those in children given 15,000 µg of retinol, and higher in children fed 8 g of red palm oil daily. At the end of three months, however, the serum levels of retinol had decreased from the one-month value but remained higher than the initial value in all the groups. At the end of three months, serum levels were similar in the groups fed vitamin A or 8 g red palm oil while it was lower in the group receiving 4 g. The results of this short-term (3 months) study indicate that the effect of 15,000 µg of synthetic vitamin A given in a single dose is equivalent to 8 g red palm oil fed daily for three months. They also indicate that the retinol equivalent of 1 µg β-carotene present in red palm oil is about 0.3 µg .

In a study by Chadha and Sharma [17] in New Delhi, the feasibility of sustained consumption of red palm oil incorporated into the home diets of 5- to 12-year-old slum children was investigated employing case-control design on a microscale. The diets of 65 children presenting abnormal conjunctival impression cytology with and without clinical signs of vitamin A deficiency were supplemented with 10 g of red palm oil per child per day. Twenty-five children from the adjoining block served as controls. There was some resistance from the mothers to using the oil, but about 50% of the children accepted the red palm oil. Significant improvement was observed in the conjunctival impression cytological status of the experimental group compared with the control group. Reversal of deficiency signs were higher at three and five months than at one month in the group given red palm oil. This study demonstrated the feasibility of feeding red palm oil to children in their home diets, which can be effective in overcoming vitamin A deficiency.

## Introduction of red palm oil into the supplementary foods distributed under the Integrated Child Development Services (ICDS) scheme

The ICDS scheme was introduced in India during 1975–76, and currently 4,200 ICDS blocks including 3,187 rural, 273 urban, and 740 tribal blocks are in operation in different parts of the country. One of the services provided by the ICDS scheme is supplementary nutrition for mothers and children, covering 20.6 million children and 3.6 million mothers. ICDS projects offer an excellent opportunity to improve the vitamin A nutritional status of young children and mothers of low-income groups by incorporating β-carotene–rich red palm oil into their supplementary food (table 3). The essential steps for introducing red palm oil into the supplementary feeding program to improve vitamin A status of children of low socioeconomic groups have been given elsewhere [4].

A major current limitation is the small amount of crude palm oil currently produced in India, only about 10,000 tons. The is too meager to have any impact on the total edible oil supply in the country, where the demand is nearly 10 million tons. The current production of palm oil in India should be used to produce edible-grade refined red palm oil of the type developed in Malaysia. To meet the edible oil shortage in the country, nearly three to four million tons of edible oil are currently being imported, mainly as palm olein from Malaysia. Clearly, a major agricultural effort to increase palm oil production in India is needed.

TABLE 3. Mode of delivering red palm oil (RPO) to beneficiaries through supplementary food[a]

| Type of supplementary feeding | Mode of delivery of RPO to the beneficiary |
|---|---|
| Food cooked at the feeding spot | RPO added during cooking of food |
| Ready-to-eat food distribution | RPO added at the time of processing of the food at the factory |
| Take-home food packet | RPO included in the take-home food packet with instructions to add RPO in the specified quantity to the cooked food given to the child and the mother and also to the milk and weaning food given to infants |

*a.* 5 ml RPO was given to the child and 10 ml RPO to the mother.

## Current efforts to introduce red palm oil into ready-to-eat supplementary food for use in supplementary feeding programs

A Workshop on Supplementary Nutrition in ICDS Projects in Andhra Pradesh was organized by the AP Foods on 28 December 1998. While delivering the inaugural address, I made a strong plea for the introduction of red palm oil into the supplementary food distributed to combat vitamin A deficiency among children covered in the ICDS program. This suggestion was welcomed by the participants. As a consequence, the director of the National Institute of Nutrition (NIN) and the managing director of AP Foods took this as a joint project. AP Foods was responsible for developing a food incorporating red palm oil, and NIN was responsible for testing the effect of the carotene-fortified supplementary food on the vitamin A status of children in an ICDS area in Andhra Pradesh. This project has been started, and the following is the current state of its progress [18].

AP Foods has completed multiple trials to enrich different ready-to-eat food preparations with refined red palm oil (Carotino). They have succeeded in incorporating red palm oil into two of their products, a powder form and an extruded product. Red palm oil was incorporated into the powdered form by direct mixing, and the extruded product was coated with red palm oil by a spraying technique. Both products were prepared with and without an antioxidant, BHA (0.001%). Red palm oil (Carotino) containing 500 µg carotene is added at a 4% level to the food to provide one RDA equivalent, i.e., 400 µg retinol equivalent for each child.

These supplements contain wheat flour, full fat soy flour, and sugar. In the snacks, milk powder, maize, and bengal gram are included in addition. These supplementary foods provide 425 to 450 kcal, 1 to 15 g protein, and 10 g fat per 100 g.

The stability of carotene in the products and their acceptability were tested at NIN. The products were well accepted, with a score close to 3.5 out of a maximum score of 5.0. Whether or not the product contained the oxidant BHA, stability tests showed that carotene in the supplementary food was less stable in the powdered form than in the extruded pellet form. At the end of three months, the carotene content was more than 60% in the pellet form, whereas it was less than 40% in the powdered form. It is proposed to prepare the supplementary food in a biscuit form and test the stability of carotene in it. Whatever may be the final product selected for feeding, carotene will be added to compensate for the expected carotene loss. The actual amount of red palm oil (Carotino) incorporated into the food would be about 7% in extruded food and 10% in the powdered form.

NIN is now planning the next phase of the study to evaluate these carotene-containing supplementary foods developed by the AP Foods in the field (an ICDS area) on growth and vitamin A status of children.

## Earlier attempts to incorporate red palm oil in the supplementary food in an ICDS area

A study was undertaken by the Department of Foods and Nutrition of the local Agricultural University (Acharya NG Ranga Agricultural University) to evaluate the operational feasibility of introducing red palm oil into the supplementary feeding programs of ICDS centers [19]. This team studied the acceptability of supplementary food containing red palm oil (2 g of deacidified and deodorized red palm oil per child) and any problems faced by the village volunteer (Anganwadi) worker with the feeding, factors affecting consumption, and the impact of consumption of this food on the vitamin A status and morbidity of the children. The results appear to indicate that red palm oil supplementation increased the attendance at the center and resulted in a decrease in clinical signs of deficiency and in morbidity in the children. If these efforts to introduce red palm oil in the supplementary feeding program of the ICDS continue, there is hope that the incidence of vitamin A deficiency among children can be prevented or reduced to a large extent.

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# Reducing subclinical vitamin A deficiency through women's adoption of appropriate technologies in Tanzania

Genererose Mulokozi, Laurent Mselle, Joseph Mugyabuso, and Charlotte Johnson-Welch

## Abstract

*Many at-risk populations in developing countries are vitamin A deficient. Improvement in the vitamin A status of preschool children would increase their chances of survival and improve their health. Progress has been made in combating severe forms of vitamin A deficiency, yet the extent of subclinical vitamin A deficiency is worrisome. Strategies such as supplementation, food fortification, and dietary diversification have had some impact, but efforts must be made to enhance their effectiveness. One promising strategy is to increase women's access to food-processing technologies that extend the availability of vitamin A and provitamin vitamin A–rich foods, reduce nutrient losses due to traditional processing methods, and improve the hygienic and nutritional quality of the dried food products. Because women are key to household nutrition, improving their access to such technologies would increase women's productivity and enhance the effectiveness of their nutrition-promoting behaviors. The Tanzania Food and Nutrition Centre (TFNC) within the Ministry of Health, and working with the Ministries of Agriculture and Livestock Development and Community Development, Children and Women's Affairs, implemented an intervention research study in rural Tanzania to promote women's adoption of improved solar-drying technologies for preserving vegetables and fruits and to improve children's dietary intake of provitamin A–containing foods. Children whose mothers adopted the improved solar dryers consumed significantly more foods rich in vitamin A and provitamin A (*p *< .001). The β-carotene content of green leafy vegetables dried in the improved enclosed dryers was better than that of vegetables dried using traditional methods. These results suggest opportunities to reduce seasonal subclinical deficiencies among children in this semiarid rural area of Tanzania.*

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## Introduction and rationale for the study

It is estimated that six percent of the Tanzanian population is vitamin A deficient; 98% of these are children under six years of age [1–3]. Subclinical deficiencies are particularly prevalent in the drought-prone areas of the country. A 1991 study conducted during the dry season in Singida District found that 60% of 226 children less than six years old had serum retinol levels less than the cutoff value of 20 μg/dl [4]. A similar study conducted during the rainy reason found that 35% of children had serum retinol levels that fell below the cutoff [5].

To address this nutritional problem, the government of Tanzania employs a number of strategies, including information-education-communication (IEC), promotion of red palm oil and home gardens, and universal capsule distribution for children less than two years old and women within four weeks postpartum. Food-based interventions are particularly appropriate for reducing subclinical vitamin A deficiencies, yet their effectiveness is limited by seasonal shortages of vitamin A–rich foods. Over the past 10 years, the Tanzania Food and Nutrition Centre (TFNC) and the Ministry of Agriculture have implemented a series of community-based activities in Singida Rural District to promote the production, preservation, and consumption of vitamin A–rich fruits and vegetables.

Most households in Tanzania use traditional sun-drying methods. Foods are placed on mats or the bare ground and exposed to direct sunlight. Limited inputs are needed to use this technique (principally, the food source and women's time). However, the preserved foods often become contaminated and can be easily blown away by the wind, direct sunlight degrades the carotenoids in the foods, and their natural color may change, reducing their appeal. TFNC developed improved solar dyers to reduce the exposure of foods to contaminants and direct sun, the time needed for drying, and the humidity levels of the foods so that the dried foods could be better stored [6–8]. The output is a nutritionally improved food product with a more consistent quality that has increased market value. An added value is that women, who are key to household nutrition, improve their productivity, thereby enhancing the effectiveness of their nutrition-specific caregiving and productive behaviors and improving their contributions to nutritional outcomes [9, 10].

Lessons learned from a 1992–1994 project that introduced solar dryers to communities in the Singida Rural District were used to develop the project reported here. Specifically, communal ownership of donated dryers appeared to be a barrier to use and maintenance, because individual users felt they had no control over the dryers or their outputs. Second, the large size of the dryers made them expensive to build and maintain. Finally, community members had little awareness of the advantages the technology offered over traditional drying methods.

Convinced that the dryers could be modified to enhance their impact on nutritional outcomes, researchers at TFNC with colleagues in the Ministry of Agriculture and the Ministry of Community Development, Children and Women's Affairs implemented an intervention research study between 1995 and 1998.* The study explored three ways to increase the dryers' nutritional impact. By designing models that responded to women's needs, more dryers might be constructed, increasing the production of dried foods. Second, by developing an education strategy that ensured that all community members received the same basic information, families might adopt the dryers and feed the nutritionally rich dried food products to their 12- to 71-month-old children. Third, providing women with additional nutritional information and skill training might make them feel more empowered to access the resources they needed to adopt the improved technology. The conceptual framework that guided the study's design, implementation, and evaluation is shown in figure 1.

## Description of the intervention

The intervention aimed to promote women's adoption of the improved solar dryer and the consumption of dried provitamin A–rich foods by children 12 to 71 months old. Two solar dryer designs were developed in response to women's preferences for home-sized dryers and a choice of materials, wood and mud brick. The dimensions of the box-like wooden dryer were: height at the back, 20 cm; height at the front, 30 cm; width, 75 cm; length, 90 cm. The cabinet was raised about 1 meter off the ground and inclined at about 6° to capture more sunlight. The dimensions of the mud brick dryer were: height at the back, 20 cm; height at the front, 30 cm; width, 80 cm; length, 100 cm.

The wooden dryer was lightweight and portable so that women could position it to maximize trapping solar energy at different times in the day, thus enhancing its effectiveness, and bring it inside for safekeeping. It was, however, somewhat expensive (approximately US$10), including materials and labor of the artisan.

These costs are comparable to the market value of seven chickens or a bag of maize. On average, a middle-income household in this area of Tanzania owns five cattle, five goats, and six chickens (an animal wealth equivalent of US$440).

The mud brick dryer was less expensive (US$4) and more effective in drying because of its greater heat retention, but it was prone to deterioration over time. The annual maintenance costs for either dryer were approximately US$2 for plastic sheets and wire mesh for the drying tray. Bulk purchasing of black cloth or plastic sheeting for the dryers was facilitated by TFNC to reduce the unit cost.

Either dryer could be constructed in one day. Eleven carpenters and 11 masons were trained in solar dryer construction and maintenance. Women chose the dryer they wanted, provided all materials needed for construction, and worked alongside the trained artisans to learn how to construct and maintain the dryers. Agriculture extension agents and executive officers made home visits to support adopters.

Community sensitization and mobilization occurred in two one-day meetings led by project staff. The first

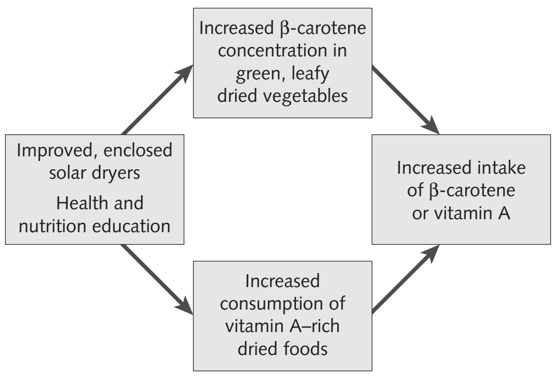


FIG. 1. Conceptual framework: linking solar dryers, nutrition, and health education to vitamin A intake

* Support for this study was provided by the Opportunities for Micronutrient Interventions (OMNI) Research, a project of the Office of Health and Nutrition, Bureau for Global Programs, Field Support and Research, United States Agency for International Development (USAID).

session sensitized all community members to the problem of vitamin A deficiency, its prevention, control, and treatment, and the contribution that improved solar dryers could make to alleviate this nutritional problem. Only women attended the second day's session. They received additional information on vitamin A deficiency and locally available vitamin A–rich foods, and they learned how to use the improved solar dryers and techniques for proper food storage, handling, and preparation. Dryer construction followed the awareness-raising, skill-training sessions.

## Study design and methodology

The study hypothesized that improved technology, skills training, and nutritional education would significantly increase the consumption of vitamin A–rich foods, thereby reducing seasonal vitamin A deficiency. The study trained women in business planning and management to encourage production of dried food products for markets and to increase women's income. The data related to that component are not included in this paper. Eight (of 29) communities in the Ilongero Division of Singida Rural District of Tanzania were randomly selected as intervention (five) and control (three) sites. Using nonreplacement sampling, seven other communities were randomly selected and included for baseline assessment of the prevalence of vitamin A deficiency in the area.

Preintervention data were collected from 250 households in intervention communities and 150 households in control communities. In each case, households were randomly selected based on the presence of a child between the ages of 12 and 71 months. Postintervention data were collected from 239 of the intervention community households and 126 of the control households (4% and 16% loss to follow-up, respectively). The dietary intake of young children in 36 adopter households was compared before and after the intervention period with children in 174 nonadopter households (also in the intervention communities). Although adopters and nonadopters were self-selected, this comparison was made to suggest optimal levels of nutritional outcomes that could be achieved by adoption of the improved solar dryer in combination with skill training and nutritional education.

Baseline data were collected through household surveys and included household demographics, vegetable availability, food-drying practices, income-generating activities, and household expenditures. A market survey to determine the availability of dried foods and anthropometric measurements (e.g., weight and height) of women and children 12 to 71 months of age were undertaken at baseline only. Pre- and postintervention data were collected during the dry season, when fresh fruits and vegetables were least likely to be available and dried food products were more available. The β-carotene content of vegetables was determined using high-performance liquid chromatography (HPLC) techniques.

The Helen Keller International (HKI) food-frequency method was used to assess the community risk of vitamin A deficiency (establishing prevalence at baseline) and to evaluate the effects of the intervention [11]. This method yields scores that reflect the number of days per week that children under five years old were reported to have consumed animal and plant foods rich in vitamin A. According to HKI guidelines, communities with an animal source index of less than 4 days/week or a mean weighted total food-frequency index of less than 6 days/week are considered at risk of vitamin A deficiency. Biochemical indicators were not used due to funding constraints.

Monitoring data, including the number of adopters, type of dryers constructed, frequency of use, problems encountered, and solutions employed, were collected throughout the project. Focus-group discussions and key informant interviews with women and other community members also were conducted throughout the study to assess knowledge and attitudes about the new technology.

### Data analysis

Epi Info version 6.0 and SPSS/PC+ were used for analysis. Chi-square analyses were used for categorical data, and *t* tests or nonparametric methods, e.g., Mann-Whitney (Wilcoxon), were used for continuous data. Comparisons were made within communities (that is, before and after), between the five intervention communities and the three controls, and between adopter and nonadopter households in the intervention communities.

### Ethical approval

The Research and Ethics Committee of Tanzania Food and Nutrition Centre, community leaders, and Regional and District Agricultural and Community Development Officers approved the study.

## Results

All 15 communities assessed for being at risk for vitamin A deficiency had scores that fell below the HKI cutoff. The mean scores were 3.2 in the five intervention communities, 3.6 in the three control communities, and 3.5 in the remaining seven. These findings suggest that this drought-prone region is at high risk of vitamin A deficiency, and they are consistent with other studies [4, 5].

Table 1 summarizes intervention and control group

TABLE 1. Preintervention characteristics of women in the sample (% of total)

| Characteristics of women | Intervention group ($N = 250$) | Control group ($N = 150$) | $p$ |
|---|---|---|---|
| Literate | 4.6510e+11 | 3.8e+10 | $< .05$ |
| Formal education | | | $< .001$ |
| Married | | | NS |
| Dried vegetables in sun | | | $< .05$ |
| Dried fruits in sun | | | $< .005$ |
| Earned income | | | NS |

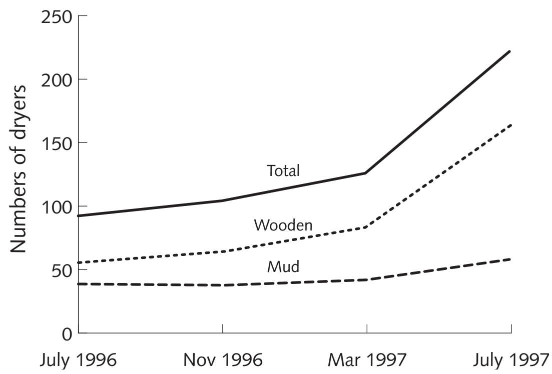


FIG. 2. Adoption rate according to dryer type

characteristics. Although women were not perfectly matched at baseline, they did not differ significantly in terms of factors that might influence adoption of the technology and its use. Where differences did occur, e.g., literacy and education, and drying vegetables and fruits, they appeared to cancel each other out.

### Women's knowledge of solar drying

It was expected that women would adopt the dryers and feed their children the value-added food products if they believed the dryers were beneficial and affordable. A majority of women who adopted the improved, enclosed solar dryers correctly recalled a number of the dryers' benefits as presented in the education sessions. These included more hygienic drying (89%), greater retention of the food's natural color (60%), and higher vitamin retention (60%). Over two-thirds (69%) said that good dryer performance was a principal motivation for adopting the new models.

### Adoption of the improved, enclosed solar dryers

The number of dryers constructed increased from 92 in July 1996 to 220 in July 1997 (fig. 2). Over the same time period, the ratio of wooden to mud-brick dryers increased from 1.4:1 (54 versus 38) to more than 3:1 (163 to 57). Although the wooden dryers were more expensive to build, the women preferred them for reasons of portability, maintenance, and durability. Fifteen months after the introduction of the improved technology, a total of 210 households had built one or more dryers.

Attendance in the education sessions influenced adoption of the enclosed solar-drying technology. The seminars were attended by 300 (12%) of the women in the five intervention communities. Of these, 189 women (63%) adopted the dryer. Another 21 women who did not participate in the education sessions also adopted the technology, accounting for the 210 adopter households. However, these adopters represent only 8% of all households (2,500) in the five intervention communities.

### Production of dried foods

Changes in the amounts of dried foods produced would be expected if women constructed the dryers (given higher efficiency of the dryers as compared to traditional methods) and if they had sufficient amounts of fresh fruits and vegetables for drying. Reflecting findings from other studies and this study's baseline, drying is nearly universal in these communities. Indeed, there was very little difference between the proportion of women in intervention and control communities who reported drying vegetables: 88% and 94%, respectively, at baseline and 99% and 98% one year later. On the other hand, adopters produced on average 55 liters after one year as compared to only 33 liters for nonadopters in the intervention communities. Adopters also dried significantly larger quantities of a variety of vegetables that were cultivated in home gardens than did nonadopters ($p < .05$)

### β–Carotene content of dried vegetables

The study compared the amount of β-carotene in vegetables blanched, but not dried, with the same blanched varieties dried by the traditional open-air direct sun method and with those dried in the improved, enclosed solar dryer (table 2). In general, samples dried in the enclosed solar dryer retained more of their β-carotene content (between 56% and 90%) than those dried using the traditional open-air direct sun drying method (between 49% and 65%).

### Dietary intake of vitamin A–rich foods

The HKI food-frequency method was used to evaluate the effects of the intervention package. Data were collected during the dry seasons in October 1995 and October 1997. Figure 3 shows that the HKI food-frequency scores in the two sets of communities at baseline were similar, with mean scores of 3.2 for the intervention group and 3.6 for the control. At postintervention, there was a significant difference in

TABLE 2. β-Carotene content[a] of green leafy vegetables blanched and then dried by the traditional direct-sun method or by using an enclosed solar dryer

| Vegetable | Not dried (μg/g) | Direct sun | Enclosed dryer |
|---|---|---|---|
| | | μg/g (% retained)[b] | |
| Ngwiba | 554 | 308 (56) | 499 (90) |
| Cowpea leaves | 526 | 296 (65) | 462 (88) |
| Mganani | 917 | 484 (53) | 776 (85) |
| Pumpkin leaves | 592 | 287 (49) | 426 (72) |
| Sweet potato leaves | 715 | 389 (54) | 470 (66) |
| Amaranths | 677 | 368 (54) | 449 (66) |
| Maimbe | 588 | 305 (52) | 330 (56) |

*a.* Reported content is the average of three tests using one sample from each of three communities.
*b.* Percent of β-carotene retained is based on amount of β-carotene in blanched undried sample.

HKI food-frequency scores between the intervention and control communities (5.7 and 4.1, respectively; $p < .001$), and the increase was significant only in the intervention group ($p < .001$).

Food-frequency scores were examined to determine which foods contributed the most to the scores. There was no difference in plant food scores for intervention or control groups at pre- and postintervention (mean scores, 1.3). Conversely, animal food scores increased significantly only in the intervention group, remaining constant in the control group. It appeared that the overall change in HKI score in the intervention group was due to an increase in animal foods rich in vitamin A, particularly dried whole sardines (dagaa).

HKI scores for children in adopter and nonadopter households within the intervention communities were explored to determine the effect of the technology package. Adopter households had significantly higher mean HKI scores than nonadopter households (7.48 and 4.75, respectively)(fig. 4). This might reflect increased availability of dried food products and increased awareness of the nutritional value of the dried food products. It also might be an indirect effect of the higher socioeconomic status of adopter households that permitted them to construct the dryers and purchase more animal vitamin A food sources.

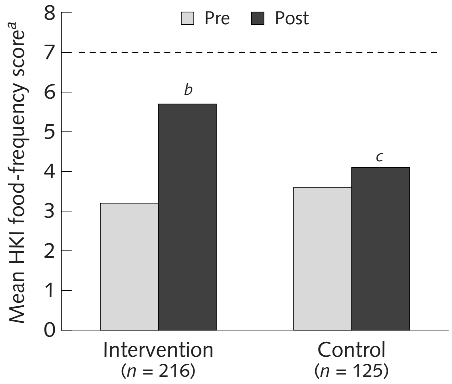


FIG. 3. Pre- and postintervention HKI food-frequency scores of children in intervention and control communities.

*a.* Calculated as days on which animal food sources were consumed/week + [(days on which plant food sources were consumed/week)/6].
*b.* Significantly higher than preintervention score for intervention group ($p < .001$).
*c.* Significantly lower than postintervention score for intervention group ($p < .001$)

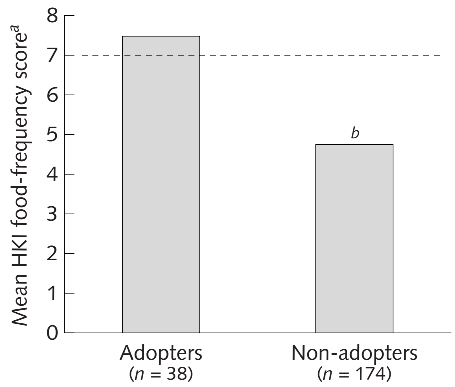


FIG. 4. Postintervention HKI food-frequency scores of children in adopter and nonadopter households.

*a.* Calculated as days on which animal food sources were consumed/week + [(days on which plant food sources were consumed/week)/6].
*b.* Significantly lower than adopters ($p < .001$)

## Discussion

The purpose of this study was to investigate whether community members, particularly women, would adopt improved solar dryers, and whether nutritional education, skill training, and use of improved solar dryers would lead to improvements in the dietary intake of vitamin A by children 12 to 71 months old. The findings suggest that women did adopt the new dryers and that the adoption rate was highest for those who had been exposed to the full intervention package and who came from economically better-off households. Adopters had significantly higher mean socioeconomic scores than nonadopters (6.1 versus 4.5, $p < .01$). The dryers were used predominantly for dark-green leafy vegetables, and leaves dried in the improved enclosed solar dryers had considerably higher concentrations of β-carotene than did those dried using the traditional manner. They were also used for animal foods that were rich in vitamin A, particularly dried whole sardines (dagaa).

Because the number of adopters was relatively small among all sampled households, it is likely that the contribution of the improved solar dryers to explaining the increase in HKI scores of the intervention group was minimal. This suggests that the nutritional education component of the intervention might have had a larger effect on the main nutritional outcome than did the improved solar dryer component through raising awareness of mothers and families to give their young children more animal-based foods. However, the dryers were efficacious and effective in producing a value-added food product. Recent evidence suggests that adequate consumption of green and yellow vegetables can be sufficient to maintain adequate stores of vitamin A [12]. Thus, continued promotion of improved solar dryers and consumption of vitamin A–rich foods has the potential for reducing subclinical vitamin A deficiencies in children living in areas similar to the study sites.

### Explaining the large effect of nutritional education

The large increase in children's consumption of animal sources of vitamin A was a surprise. Although the education sessions promoted consumption of all locally available vitamin A–rich food sources, including animal products, the intensity and duration of the education component were quite limited. Although extension workers reinforced the nutritional education messages during home visits, their attention was principally on construction and use of the improved solar dryers. So, what might explain this large effect? It is likely that the nutritional education simply reinforced educational messages that were part of earlier nutrition activities in the same communities. It is also conceivable that the dryers had an indirect effect on uptake and use of the educational information. Development practice has long demonstrated that education is far more likely to prompt action when it is part of a package of interventions, some of which are material in nature, such as seeds, credit or, in this case, dryers.

### Explaining who adopted the technology and why

The dryers were well liked by women in the intervention communities because they increased women's productivity and efficiency. Women spent less time staying close to the enclosed dryer to keep animals away and therefore they could perform other activities. Because the temperature in the enclosed dryer was intensified, less time was required to dry a batch of foods, so women could produce more batches. Finally, although the wooden dryers were more expensive to construct, women preferred them because they were lighter in weight and portable, so they could position the dryers to maximize production levels.

However, only 8% of all households chose to adopt the improved technology. This might be an income effect. The participants had to save funds to purchase the materials to construct their dryers, and this might have contributed to the slow but steady rate. Further, adopters had higher socioeconomic status than nonadopters, a consistently reported pattern in technology development literature [9, 13, 14]. Early adopters could risk trying the new technology because they had a financial cushion. Once the experience of these early adopters demonstrates the costs and benefits of the dryers, others may be more willing to invest their scarce resources to construct their own dryers.

Another factor that might have influenced the adoption rate was the behavior of the artisans. Although the dryers were relatively easy to construct, the local trained workers were an efficient means to diffuse the technology. However, project staff learned that the artisans charged inflated prices for their services, which might have discouraged community members from using their service and limited the adoption rate. Given that the artisans are not needed for actual construction, they could be eliminated as intermediaries if alternative and equally efficient ways for training household members were found.

## Recommendations

The following recommendations suggest actions to find sustainable, acceptable, and affordable means to reduce subclinical vitamin A deficiency in rural areas similar to the study communities. Given the pivotal role women play in household nutrition, improving their access to technologies that increase women's efficiencies and productivity is long overdue.

### Continue to promote the technology

The improved solar dryers were effective in reducing women's labor burden and in improving the nutritional quality of dried food products over traditional drying methods. They also could reduce seasonal shortages in foods that are particularly nutrient-dense. Beyond the dryers' contribution to reducing vitamin A deficiency, they also might contribute to mitigating the effects of the HIV/AIDS epidemic. The prevalence rate of HIV/AIDS in Tanzania is growing [15], and with limited options available for treatment, development agencies and national governments should invest in technologies that mitigate the impact of the epidemic on families [16–19]. This is particularly important because women bear disproportionate costs in terms of their social and economic vulnerability to contracting the disease, receiving care and treatment, and caring for family members [20]. Thus, promoting technologies such as the improved, enclosed solar dryers could yield benefits beyond reducing subclinical vitamin A deficiency.

#### Continue to promote production of fresh fruits and vegetables

The results suggest that the dryers enhanced the β-carotene content of the dried food products; however, this effect depends on dryer owners having access to sufficient supplies of fresh fruits and vegetables to process for off-season consumption. The Ministry of Agriculture and other relevant institutions should continue to promote the production of fruits and vegetables and explore other foods, such as orange-fleshed sweet potatoes, mangoes, and papaya, that could be processed in the new, enclosed dryers. Attention also should be given to technologies that can reduce production constraints, including low-water use technologies and rainwater harvesting for irrigation purposes.

#### Undertake a longitudinal study to determine if dietary consumption of vitamin A is sustained

The findings indicated that children's intake of animal sources of vitamin A increased over the course of the study. This is encouraging and deserves to be monitored to confirm that it is sustained. It was surprising that consumption of plant sources of vitamin A did not increase despite an increase in the amounts dried, and this also deserves attention. It should be explored whether consumption of dark-green leafy vegetables has already reached its maximum, and also whether other plant sources could be promoted for drying to enhance year-round consumption. Finally, taking into account recent biological concerns that β-carotene may have lower bioavailability and conversion to vitamin A than previously thought [21], future studies should confirm that vitamin A status (serum vitamin A levels) among young children improves following these food-based interventions.

## Acknowledgments

We are grateful to the community leaders and women in the study villages for their cooperation throughout the study; to Mr. A. Mngale from the Ministry of Agriculture in Singida Rural District for his help in designing data-collection tools to monitor adoption rates and for visiting households to collect such data; to senior officers at the regional and district levels in the Ministry of Agriculture and Livestock Development for participating in sensitization seminars and providing useful suggestions; and finally, to Dr. W. Lorri, the managing director of Tanzania Food and Nutrition Centre, for his valuable comments and encouragement.

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# Food fortification with vitamin A: The potential for contributing to the elimination of vitamin A deficiency in Africa

France Bégin, Jenny Cervinskas, and Venkatesh Mannar

## Abstract

*The control of vitamin A deficiency is a realizable goal that needs to be addressed through a combination of interventions. Among these, fortification of commonly eaten foods and condiments has great potential to help realize this goal. Fortification offers a number of strategic advantages, because it is cost effective, builds on existing food processing and delivery systems, and enhances sustainability. Proven vehicles for vitamin A fortification that are relevant for Africa include sugar, oils and fats, and cereal flours. Fortified foods cannot be expected to reach all deficient populations. However, for the large and expanding populations of all socioeconomic classes that regularly purchase and consume commercially processed foods, fortification can make an enormous difference. For those who do not have easy access to commercially processed foods, fortification at community-level mills and the use of encapsulated micronutrient sprinkles are promising technologies. Although most technologies described in this paper are ready for scale-up and large-scale application, there are a number of steps to be undertaken in order to ensure effective programs, including appropriate advocacy and communication, collaboration among several sectors, food regulations and standards, and quality assurance and monitoring.*

## Introduction

In spite of efforts over the past two decades, vitamin A deficiency is still prevalent worldwide and especially in Africa, where it is estimated that 25 to 36 million preschool children are affected by subclinical and clinical vitamin A deficiency [1]. In the Eastern and Southern Africa region alone, about 10 million children show clinical signs of vitamin A deficiency [2]. It is well known that vitamin A deficiency contributes to significantly increased risk of death in children [3]. Strategies used to combat vitamin A deficiency include supplementation with vitamin A capsules, promotion of the production and consumption of vitamin A–rich foods, food fortification, and public health measures. In many African countries, given the extent, magnitude, and severity of vitamin A deficiency, interventions that can have an immediate impact (i.e., supplementation) are needed at the same time as medium- to long-term interventions are being planned and implemented.

Supplementation with large doses of vitamin A has played a major role over the past years and will continue to do so in the forthcoming years, especially for young children who do not have access to vitamin A–rich foods. However, there is concern that this type of intervention is highly dependent on external support. In contrast, food fortification is seen as sustainable, requiring little external support or investment as it builds on existing food production and distribution systems, and therefore becomes a permanent feature. Compared with other food-based interventions, food fortification is perceived to be more cost effective [4]. Until recently, food fortification has not received serious consideration by governments, the food industry, and the public as a means to help reduce micronutrient malnutrition in Africa. Food fortification presents a great potential but requires effective public-private collaboration and social marketing to ensure that consumers demand fortified products.

Fortification is the strategy that was adopted in Europe and North America in the early part of the twentieth century to combat mineral and vitamin deficiency diseases that were prevalent. Salt was iodized in Switzerland in the early part of the twentieth century as a means to eliminate iodine-deficiency disorders. Addition of vitamin A to margarine was introduced in Denmark in 1930. During the 1930s and 1940s, milk was fortified with vitamin A, and flour was fortified with iron and B vitamins in a number of countries in Europe and North America. In the United States, although improved economic conditions contributed

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to the decrease in deaths from pellagra, it is clear that fortification of wheat flour with niacin, which began in 1938, played a significant role in the elimination of pellagra [5]. In Canada, four years after the initiation of flour enrichment in 1944, the prevalence of vitamin $B_1$ and $B_2$ deficiencies in the population dropped from almost 20% to less than 2% [6]. In all these countries, the high dependence on commercially processed foods and the automation and centralization of the food industry enabled effective fortification of foods to correct a range of micronutrient deficiencies.

### Food fortification in perspective

Food fortification involves the identification of commonly eaten foods in a country or region that can act as vehicles for one or more micronutrients and lend themselves to commercial processing. Fortification when imposed on existing food patterns does not necessitate changes in the customary diet of the population and does not call for individual compliance. It can often be dovetailed into existing food production and distribution systems. For these reasons, fortification can often be implemented and yield results quickly and be sustained over a long period of time. Moreover, as food technology is rapidly becoming global with expanding trade and investment, fortificants, premixes, and process know-how are now available internationally. However, food fortification cannot be expected to reach all populations that are deficient in essential micronutrients. When access to commercially or centrally processed food is limited–due to geography, poverty, or cultural preference—public health and welfare approaches to deliver supplements or dietary education may often be the only viable options. However, for the large and expanding populations of all socioeconomic classes that regularly purchase and consume commercially processed foods, fortification can make an enormous difference. Fortification offers a number of strategic advantages, as described in table 1. Among these, cost-effectiveness is definitely a major factor that will influence the decision of policy makers. In a study carried out by the Latin American and Caribbean Health and Nutrition Sustainable Project in 1991 in Guatemala, it was found that sugar fortification was the most cost-effective intervention that could protect the entire population for less than one-fourth the cost of supplementation. The cost of sugar fortification was estimated annually at US$0.98 per at-risk person and US$0.37 per capita for the entire population, as compared with US$1.52 for supplementation with preschool children only and US$3.63 per person at risk for dietary education and gardening projects [7]. When micronutrient programs are compared, iron and vitamin A fortification rank second and third in number of dollars gained for each dollar spent [8].

TABLE 1. Strategic advantages of food fortification

| Advantage | Explanation |
|---|---|
| Harnesses new resources | Fortification engages the market system and the private food sector<br>It also presents an opportunity to companies to develop new markets and gain new customers |
| Requires modest investment | Incremental costs often as low as 1%–2% are either passed along to the consumer or absorbed by the producer |
| Is cost-effective | Fortification reaches broad populations at minimal cost |
| Builds on existing technology | The additive equipment is already integrated into the process flow |
| Is facilitated by globalization of the food industry | Fortificants, premixes, and processing knowledge are now available internationally |
| Supports other public health strategies | Government can focus supplement delivery and dietary education on populations that have limited access to fortified foods |

## Vehicles for vitamin A fortification

Several steps and components are required in order to ensure effective fortification programs (fig. 1). The choice of food vehicle for fortification is a primary step. The food vehicle should be consumed by a sizable proportion of the population that is at risk. The vehicle should also be consumed in fairly constant amounts so that fortification levels can be accurately calculated. In the case of fortification with vitamin A, proven vehicles include sugar, cooking oils and fats, milk, and cereal flours. However, foods such as milk and margarine are usually expensive and therefore are not widely consumed by vulnerable groups. Milk consumption in Africa is low, mainly due to cultural and economic reasons. It is mainly consumed by refugee populations after reconstitution of the dry form with water.

Sugar has been successfully used as a food carrier for vitamin A in Guatemala, Honduras, El Salvador, Costa Rica, and recently in Nicaragua. In those countries, sugar is centrally processed, affordable, and widely consumed. In fact, fortified sugar supplies at least 50% of the recommended dietary allowance (RDA) for vitamin A for all people over two years of age and between 30% and 40% of the RDA values for children 6 to 14 months of age [7]. In Africa too, sugar has a potential as a carrier for vitamin A, since it is produced in many countries and sugar intakes are high enough for vitamin A fortification to increase vitamin A intake significantly [9]. In 1998, Zambia was the first African country to initiate sugar fortification with the support of USAID and UNICEF [10]. Several other

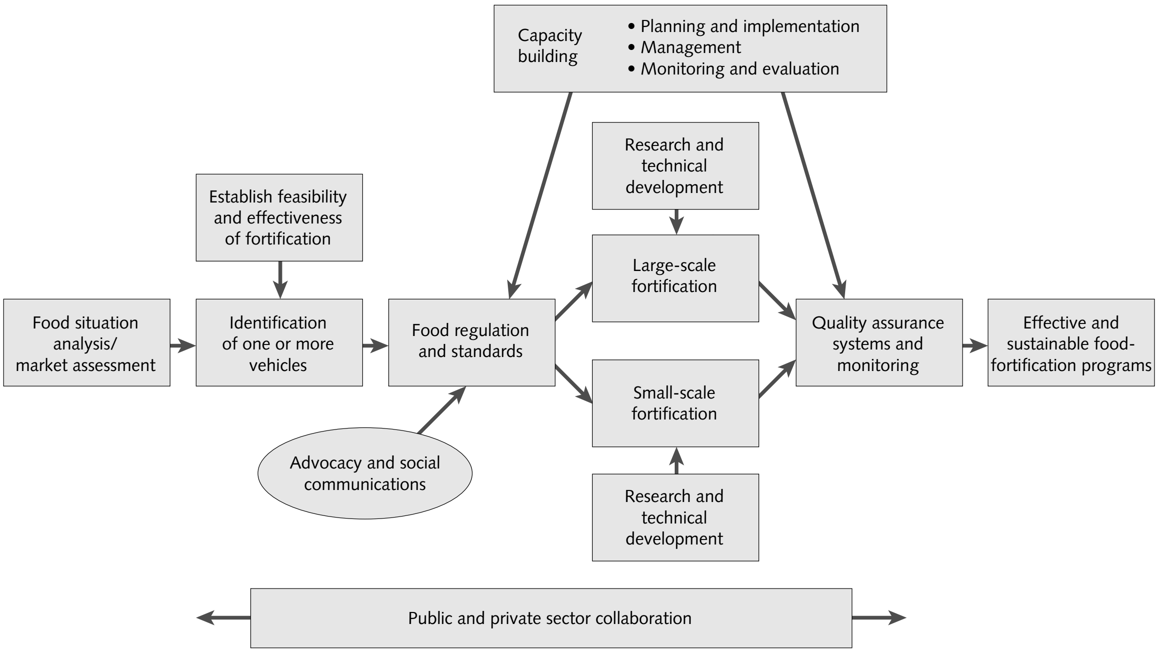


FIG. 1. Steps and components of a food-fortification program

countries in Southern and Eastern Africa are exploring the feasibility of fortifying sugar with vitamin A as one of the means to prevent vitamin A deficiency.

Oils and fats are also suitable vehicles, providing the medium from which vitamin A can be best absorbed. Fats are used in one form or another as a necessary dietary item for meal preparation. Several industrialized countries routinely fortify margarine with vitamin A, and this practice is being implemented in the Philippines and other Asian countries. A few brands of cooking oil are also fortified with vitamin A in Kenya and Malawi, among other countries. Morocco has recently implemented an oil-fortification program [11].

Red palm oil is a naturally rich source of carotenoids. Promoting its use to prevent vitamin A deficiency is particularly appropriate in many African countries that already produce red palm oil. About half a teaspoon (2.5 ml) of red palm oil consumed by a child on a daily basis can provide sufficient carotene intake (350–400 RE). However, frying the oil at high temperatures for long periods can destroy the provitamin A. The potential of red palm oil to prevent and combat vitamin A deficiency is fully discussed at length in other accompanying papers.

Cereals such as wheat, corn, and rice constitute major staple foods for several African countries, and cereal flours are logical potential carriers of multiple nutrients. Cereals contribute between 50% and 75% of energy intake of African populations. Venezuela and the Philippines have experience with fortification of cereal flour with vitamin A and other nutrients, including iron. In the Philippines, vitamin A fortification of wheat flour buns was effective in raising serum retinol levels of schoolchildren [12]. In Venezuela, the effect that vitamin A fortification of precooked maize flour had on serum retinol levels has not been evaluated, but it had a positive effect on iron status by preventing the inhibiting effects of phytate on iron absorption [13]. This is particularly advantageous in countries where fortified flour has a high phytate content.

Although cereals offer a great possibility for fortification, they are largely processed at the community level. Africa has more native grains than any other continent: it has its own species of rice, as well as finger millet, fonio, pearl millet, sorghum, tef, guinea millet, and several dozen wild cereals whose grains are eaten from time to time [14]. In countries like Burkina Faso, Mali, Niger, Chad, and Sudan, millet and sorghum are often the main staple of the diet. Fortificaion of these cereals could directly benefit the people in greatest need. However, high losses in baking would need to be taken into account in determining the level of fortification. The fact that these cereals are not generally commercially processed poses a special challenge to ensure quality and safety.

For many countries, utilizing a variety of vehicles fortified to a specified proportion of recommended dietary allowances (RDA) may provide an effective approach to increase vitamin A intake. If the consumption of a particular vehicle is limited to certain groups and sporadic in others, fortifying several vehicles provides for complementary coverage. Moreover, when a variety of foods is fortified, each with a lesser proportion of the RDA than would be added if only a single food vehicle was fortified with vitamin A in a given country, the theoretical possibility of excessive intake of a micronutrient through consumption of a single food becomes more remote. For example, in Zambia, sugar and maize meal are fortified with vitamin A. South Africa is also planning to fortify wheat flour, corn meal, and sugar. Interestingly, even if these three commodities were fortified with vitamin A, there would still be some deficit for children seven to nine years old since only 75% of their requirements would be met (fig. 2).

## Impact scenarios

The potential impact of fortification of three staple foods in improving vitamin A intake in a set of countries is presented in figures 3 to 5.* The scenarios described below are based on per capita consumption estimates based on 1997 data from Food and Agriculture Organization food-balance sheets. A number of assumptions regarding level of fortificant, nutrient stability, and consumption were made. Although these estimates are only for adult males, they give an idea of the potential for reaching all family members. For sugar (fig. 3), assuming that all centrally processed sugar was fortified with vitamin A at 50 IU/g sugar with 50% stability, for several African countries, fortified sugar could provide from 50% to more than 100% of daily requirements of adult males. For maize (fig. 4), it is assumed that 50% of the maize supply

* These figures were drawn from an unpublished report by G. Maberly, J. Bagriansky, and L. Mkondya, 2000.

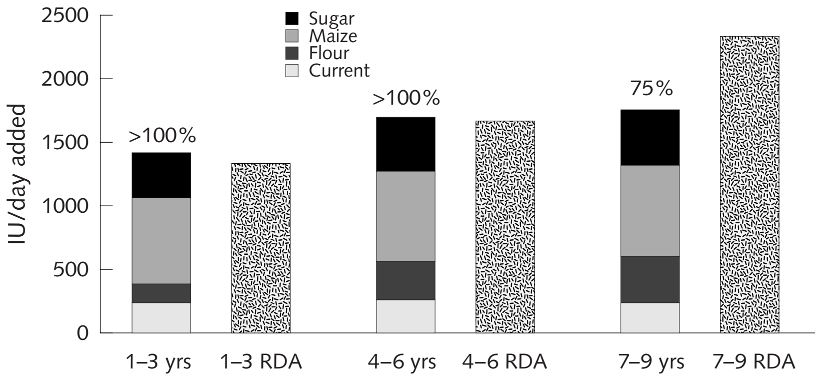


FIG. 2. Impact on lowest-income quintile of total grain plus sugar fortification. Source: Directorate, Nutrition, Department of Health. National Food Consumption Survey (NFCS), Stellenbosch, South Africa, 2000 (unpublished report)

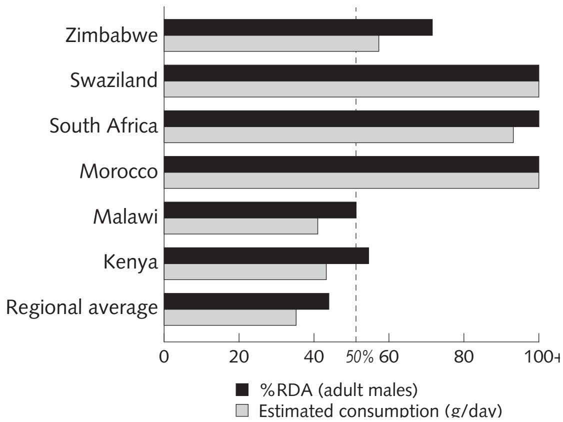


FIG. 3. Percentage of RDA supplied by vitamin A–fortified sugar. Source: Maberly G, Bagriansky J, Mkondya L. Emory University. Examining the issues. Public-private collaboration to support the elimination of micronutrient malnutrition. Unpublished report to the Micronutrient Initiative, 2000

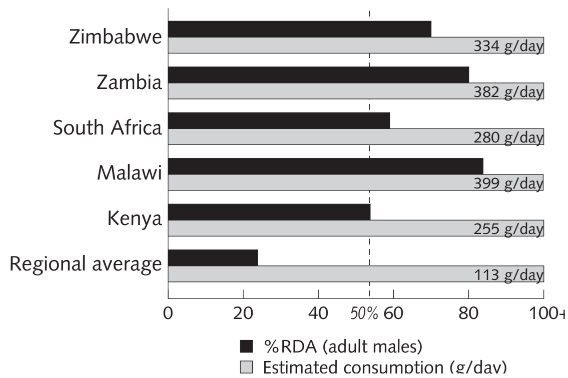


FIG. 4. Percentage of RDA supplied by vitamin A–fortified maize flour, the main staple for Angola, Benin, Congo, Central African Republic, Ghana, Kenya, Lesotho, Malawi, Mozambique, Swaziland, South Africa, Tanzania, Togo, Zambia, and Zimbabwe. Source: Maberly G, Bagriansky J, Mkondya L. Emory University. Examining the issues. Public-private collaboration to support the elimination of micronutrient malnutrition. Unpublished report to the Micronutrient Initiative, 2000

is centrally processed and that vitamin A is added at 7 IU/g maize.

For most of the countries listed in figure 4, fortification of maize could make a significant contribution to the daily vitamin A intake, providing more than 50% of the RDA for adult males. However, for the population as a whole in some countries, even the fortification of several foods (e.g., maize and wheat flours, sugar, and oil) would not have a high impact on vitamin A intake because these foods are not widely consumed (fig. 5). On the other hand, for many countries in Africa, fortification of all possible edible oil, wheat flour, corn flour, and sugar would make a significant contribution to the vitamin A needs of the population. Overall, this exercise illustrates that the consumption of staples varies widely across African nations, and that the potential impact of fortifying a staple with vitamin A on vitamin A intake by populations will vary greatly, depending mainly on the pattern of availability and consumption of that staple. The key issue is to understand and analyze the country-specific food production, processing, and distribution systems and the patterns of food intake to assess the potential contribution of food fortification to preventing micronutrient malnutrition.

## Promising innovations in fortification

Fortification of foods that are industrially processed in large-scale facilities can reach large populations, but in many countries the neediest will not be reached. Innovative ways to reach the hard-to-reach have recently been explored through fortification at point of commercial milling at community and household levels (table 2).

In Africa grains are often commercially milled at facilities that have the capacity to mill and process grains on a small scale (up to 5 tons per day). Women, or sometimes their children, bring the grains that are grown by the household for processing at mills, usually privately owned, that are located nearby or a few hours' walk away. Often the amount brought for milling is just sufficient to feed the family for up to a week and is just as much as can be physically carried by the woman to the mill (up to 15–20 kg). For a fee, the miller mills the grain into flour for the customer. The feasibility of fortifying grains milled at small-scale milling operations with multiple micronutrients, including vitamin A, is being tested in Zimbabwe, Zambia, and Malawi [15]. There is also interest in Benin in West Africa and possibly in some countries in Asia. Most of these initiatives involve a collaborative endeavor between the millers, nongovernmental organizations, the government (usually the Ministry of Health), and an international development assistance partner (e.g., the Micronutrient Initiative or UNICEF).

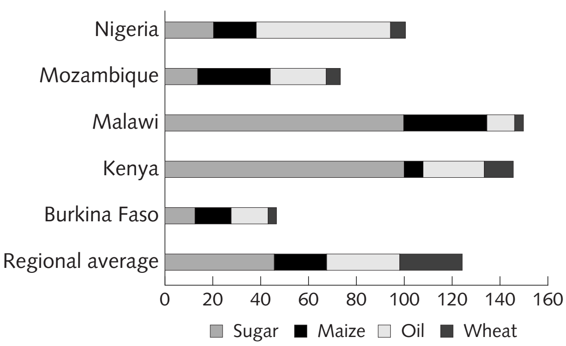


FIG. 5. Percentage of RDA supplied by vitamin A–fortified maize, sugar, wheat, and vegetable oil. Source: Maberly G, Bagriansky J, Mkondya L. Emory University. Examining the issues. Public-private collaboration to support the elimination of micronutrient malnutrition. Unpublished report to the Micronutrient Initiative, 2000

Feasibility testing will need to encompass a number of aspects, ranging from designing and introducing blending systems that are appropriate to this scale of milling, acceptance by consumers and mill operators, and economics. The development of adequate quality-assurance and control systems will be critical, and the mill operators will need to be well trained to ensure that the proper amount of premix is added to the batch and the batch is adequately blended. The addition of vitamin A to the premix will pose a special challenge to ensure consistency of mixing.

Processed complementary foods have the potential to play an important role in the diets of infants and young children. Based on analyses of nutrient requirements and the nutrient contents of typical toddler foods presented in Brown et al. [16], Brown and Lutter [17] showed that it is practically impossible to supply enough iron to meet infant and toddler requirements in the absence of fortification. Because commercially processed complementary foods are often too expensive for low-income families, small-scale fortification could be an important channel for meeting the micronutrient needs of vulnerable infants and toddlers. It would be useful to identify countries that have domestic complementary food production and determine how fortification with vitamins and other micronutrients could be incorporated into these processes.

TABLE 2. Points of fortification

| Before purchase | During commercial milling | In household |
|---|---|---|
| Large-scale milling operations | Small-scale milling operations (village mills) | During household food preparation or consumption (sprinkles) |

Another new technology that holds promise, particularly for this vulnerable group, is that of micronutrient-rich "sprinkles." The concept here is that coated micronutrients, packed in single-serving packets (2–3 g), can be added directly to the family pot or individual meals (usually a porridge with the consistency of thick soup) when the meal is eaten. In Ghana the use of microencapsulated ferrous fumarate plus ascorbic acid sprinkles was as efficacious as iron drops in treating anemia in children 6 to 24 months old when given for two months [18]. As a follow-up to this study, microencapsulated iron and zinc sprinkles are now being tested to prevent iron and zinc deficiency in anemic infants and young children receiving treatment with iron in the same group population. Vitamin A can also be included in sprinkles mixes, although the addition of vitamin A adds considerably to the cost, and special care needs to be taken to package the product so that vitamin A is protected from light and heat.

In recent years, "special" fortified foods have been developed to target specific groups, such as schoolchildren and pregnant women. For example, a micronutrient-fortified beverage drink powder was tested in Tanzania in schoolchildren [19] and more recently in pregnant women. The powder mixed into water was highly acceptable to schoolchildren and proved to be efficacious in improving iron and vitamin A status of children after six months. In South Africa, biscuits containing red palm oil shortening and consumed by primary schoolchildren over three months were as effective as biscuits containing synthetic β-carotene to increase serum retinol [20]. Although these fortified foods that are customized to meet the needs of specific age or population groups are promising, some of them are nevertheless costly, because they are packaged in single-serving packets, and special packaging is required to ensure that micronutrients (especially vitamin A) are protected.

Refugees also constitute a very specific target group for fortification. As the global numbers of refugees and displaced persons depending on food aid as their sole source of nourishment increase, fortification of food aid becomes an important area for consideration. In Africa alone, it is estimated that as of July 2000, about 10 million refugees and displaced populations required assistance [21]. Since 1993, commodities distributed by the World Food Programme (WFP) have been fortified to prevent and alleviate micronutrient deficiencies. Such commodities include iodized salt; dried skim milk, edible oils, and flours fortified with vitamin A; and blended foods fortified with a variety of vitamins and minerals. In December 1998, the US Department of Agriculture announced that all of the P.L. 480 Title II refined vegetable oil donated by the United States would be fortified with vitamin A. Each year, this oil reaches about 20 million people in 40 countries [22]. However, in spite of the progress made in enhancing the nutritional quality of relief foods, clear guidelines for fortification of food aid need to be urgently developed.

## Support measures for vitamin A fortification

In addition to the components mentioned earlier (situation analysis, selection of food vehicle, and appropriate technology application), there are additional support measures that must be an integral part of a fortification program, as described briefly below.

### Advocacy and social communications

There is a need to raise the level of awareness in both the public and private sectors about food fortification as a means to prevent micronutrient malnutrition, and to elevate the priority for fortification on the agenda of African institutions (government, research, and academic) that are concerned with improved nutrition in Africa. In the case of small-scale fortification, social marketing is critical to encourage consumers to demand and consume fortified foods on a sustainable basis, given that the benefits of the micronutrients may not be readily visible.

### Food regulations and standards

There is need to develop regulations and standards for vitamin A fortification of foods and guidelines related to vitamin A fortification technology that are related to specific foods and tailor-made for each country situation.

### Quality assurance systems and monitoring

Effective monitoring and evaluation of process and impact variables is critical [23]. Measurement of food quality and fortificant levels in the foods at different points from production to consumption is an essential step to ensure that adequate quantities of the nutrient are reaching the population. This must be combined with periodic estimation of clinical and biochemical indicators of nutritional status to evaluate the impact of the intervention. Monitoring and evaluation should be built into programs as essential components to track progress and to identify problems and needs.

### Capacity building via supporting relevant training

A problem faced frequently in the developing world is the shortage of expertise to work in food-fortification programs, especially in areas such as program planning and implementation, management, monitoring, and evaluation. There is an urgent need to identify technically sound training institutions at the regional and national level around the world where food-fortification expertise can be developed.

### Private and public sector collaboration and involvement of nongovernmental organizations

Food fortification calls for a strong partnership between private and public sectors. Nongovernmental organizations can also play a useful and supportive role at the community level.

## Conclusions

There is a large untapped potential for food industries to contribute to reducing deficiencies of vitamin A and other micronutrients for millions of people in Africa. Food fortification with vitamin A has great potential as an intervention, but it is still undervalued and underused, with many decision makers in both the public and the private sectors unaware of the value of food fortification as a means to prevent micronutrient malnutrition.

Although much of the food eaten is grown and processed at the household level in Africa, especially in the rural areas, there are many food items in the diet that are centrally processed in large-scale commercial operations. Such foods (e.g., wheat flour, corn flour, sugar, vegetable oil, and complementary foods) can serve as viable food vehicles for fortification and have been fortified in both industrialized and developing countries for many years. For the large and expanding populations of all socioeconomic classes in Africa that regularly purchase and consume commercially or centrally processed foods, food fortification can make an enormous difference.

For those who do not have easy access to commercially processed foods, there are a number of promising technologies (e.g., fortification of small batches of milled cereals or complementary foods in community mills, sprinkles, beverages) now under development and testing.

Food fortification presents a great potential but requires effective public-private collaboration and social marketing to ensure that consumers demand fortified products. Above all, food fortification will have to take a place among the top priorities in national plans and actions to improve nutrition in Africa, alongside strategies such as supplementation, dietary improvement, and public health measures.

## Acknowledgments

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# The potential of red palm oil-based shortening as a food fortificant for vitamin A in the baking industry

A. J. S. Benadé

## Abstract

*Vitamin A deficiency is a public health problem in many developing countries. There is general consensus that food-based approaches are viable and sustainable options for addressing vitamin A deficiency in populations. One good example is the fortification of food, which, if properly monitored, could make a significant contribution towards improving the vitamin A status of a population. In this respect the food industry could play a pivotal role. We proved that the incorporation of a red palm oil-based shortening (Carotino) in the baking process of a nutritional biscuit was as good as synthetic β-carotene in reducing vitamin A deficiency in schoolchildren. As a result we looked at the possibilities of introducing Carotino into other products as a means of fortifying them with β-carotene. Using traditional recipes and food-composition data, we identified a variety of products which, when baked with Carotino shortening, could provide from 15% to 200% of the RDA for β-carotene per portion of product consumed. Even if these products are not consumed on a regular basis, their contribution towards addressing vitamin A deficiency could be significant and its use in the baking industry worth promoting.*

## Introduction

Vitamin A is an essential micronutrient for the normal functioning of the visual system, growth and development, maintenance of epithelial cellular integrity, immune function, and reproduction. Although there are many cost-effective approaches to reducing vitamin A deficiency, subclinical deficiency probably still affects up to 250 million preschool children and unknown numbers of school-age children, adolescents, and pregnant women. Subclinical vitamin A deficiency contributes enormously to elevated morbidity and mortality in many age groups and is a public health problem in many developing countries [1].

There is general consensus that food-based approaches are viable and sustainable options for addressing vitamin deficiency in populations. One good example is the fortification of food, which, if properly monitored, could make a significant contribution towards improving the vitamin A status of populations. In this respect, the food industry could play a pivotal role.

Substituting red palm oil-based shortening (Carotino) for other industrial fat in the baking of a biscuit can be as effective as synthetic β-carotene in reducing vitamin A deficiency in schoolchildren [2]. We considered the possibility of introducing Carotino shortening into other products as a means of fortifying them with β-carotene. Carotino shortening contains about 450 ppm total carotenoids (of which about 60% is β-carotene) and 500 ppm vitamin E (tocopherol/tocotrienol). The carotenoid content of Carotino is given in table 1 [3].

## Methods

By using commercial recipes and food-composition data [4], several potential products were identified in which Carotino could replace the baking fat in the

TABLE 1. Carotenoid content of Carotino

| Ingredient | Amount (mg/100 g) | RE |
|---|---|---|
| β-Carotene | 28,000 | 4,666.6 |
| α-Carotene | 17,500 | 1,458.3 |
| *cis*-α-Carotene | 0.125 | 10.4 |
| γ-Carotene | 0.015 | 1.3 |
| β-Zeacarotene | 0.035 | 2.9 |
| Others | 0.275 | — |
| Total | | 6,139.5 |

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Mention of the names of firms and commercial products does not imply endorsement by the United Nations University.

recipe. The selection of individual recipes was based on the following criteria: First, the color of the final product should not be adversely affected by Carotino. Second, the amount of fat used in the recipe must be such that when replaced with Carotino, the amount of β-carotene in the final product will be in accordance with general practices in fortification, namely more than 15% of the recommended daily allowance (RDA) for β-carotene and vitamin E. Third, the portion sizes should be acceptable and realistic.

## Calculations

The fat content of the final product was used to calculate the amount of fat present in an edible portion. Substituting this amount of fat with Carotino, the amounts of carotenoids expressed as retinol equivalents (RE) and the amounts of tocopherol and tocotrienol expressed as tocopherol equivalents (TE) contributed by Carotino were calculated and expressed as a percentage of the RDA.

## Results

Calculations based on 13 different confectionery products are summarized in table 2. Depending on the age of the consumer and the fat content of the final product, a portion of Carotino product consumed can contribute 20% to 85% of the RDA for RE and 10% to 51% of the RDA for TE.

Figure 1 shows a comparison of RE and TE content of some products baked with Carotino and margarine. Confectionery baked with Carotino contains about four times the amount of RE than those baked with unfortified shortening (54% RDA and 13% RDA, respectively). Vitamin E was affected minimally (19% RDA and 23% RDA, respectively) by replacement of margarine with Carotino.

TABLE 2. Retinol equivalents (RE) and tocopherol equivlents (TE) per portion of various food products

| Product | Fat content (%) | Portion (g) | % RDA RE | | % RDA TE | |
|---|---|---|---|---|---|---|
| | | | 7–10 yr | >10 yr | 7–10 yr | >10 yr |
| Carotino biscuits | 16.0 | 45 | 62 | 54 | 37 | 26 |
| Banana loaf | 10.8 | 50 | 46 | 41 | 27 | 19 |
| Bread, maize meal | 11.3 | 50 | 48 | 42 | 29 | 20 |
| Cake, home-made | 11.8 | 50 | 48 | 42 | 29 | 20 |
| Chocolate cake | 12.9 | 50 | 55 | 48 | 33 | 23 |
| Cookies, plain | 13.4 | 20 | 23 | 20 | 14 | 10 |
| Oat crunchies | 23.4 | 25 | 50 | 44 | 29 | 20 |
| Carrot cake | 19.7 | 50 | 85 | 74 | 51 | 36 |
| Fruitcake | 12.9 | 50 | 55 | 48 | 33 | 23 |
| Cookies, shortbread | 27.2 | 20 | 46 | 41 | 27 | 19 |
| Crackers | 24.6 | 33 | 70 | 62 | 41 | 29 |
| Gingerbread | 12.6 | 50 | 54 | 47 | 33 | 23 |
| Scone, whole wheat | 12.6 | 50 | 54 | 47 | 33 | 23 |

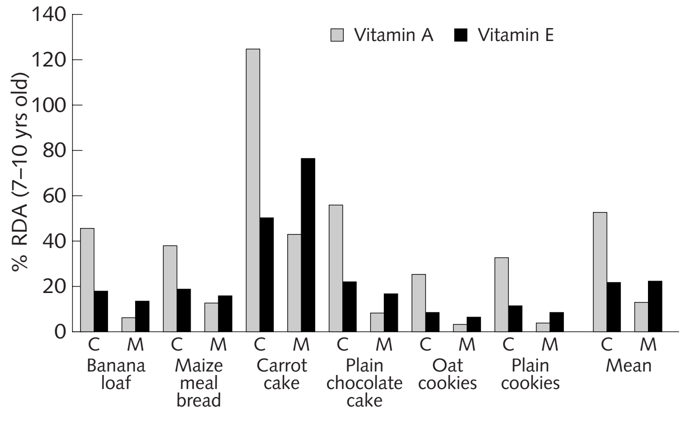


FIG. 1. Vitamin A and E content per portion of various food products baked with Carotino (C) or margarine (M)

## Discussion

The incorporation of Carotino shortening into a shortbread type of biscuit proved to be a viable option for fortifying biscuits with β-carotene. Carotino is as effective as synthetic β-carotene in improving the vitamin A status of children with marginal vitamin A deficiency [2].

Replacing standard commercial baking fat with Carotino also introduces a host of other advantages into the final product. The high tocopherol/tocotrienol content of Carotino (>400 ppm) provides excellent antioxidant properties, which are important in terms of shelf life under varying conditions. Tests carried out by our group showed that biscuits baked with Carotino have a shelf life of more than nine months. This antioxidant activity eliminates the necessity for adding antioxidants to the baking mix.

Products baked with Carotino have a constant and uniform level of β-carotene content throughout. In our experience, this was difficult to achieve when synthetic β-carotene has to be blended into standard commercial baking fat. Even when a given Carotino product is produced by different manufacturers, a uniform product with only very small variations in the β-carotene content can be obtained.

Carotino baking fat has other health advantages that make it superior to any other product available to the baking industry. Because Carotino is a nonhydrogenated fat, it contains no *trans*-fatty acids. *Trans*-fatty acids have been associated with an increased risk of ischemic heart disease [5] and impairment of fetal development [6]. The relatively high carotenoid, tocopherol, and tocotrienol content is a unique property of Carotino shortening. These natural antioxidants fulfil important functions in the body by acting as scavengers of the damaging oxygen free radicals that play a role in cellular aging, atherosclerosis, and cancer [7, 8].

Our calculations, based on standard recipes, showed that when Carotino baking fat replaced standard margarine or baking fat in recipes containing around 10% fat, portion sizes as small as 16 g (cookies) can contribute 20% to 30% of the RDA for RE of vitamin A. With portion sizes of 50 g, the contribution to the daily retinol requirements can be as high as 50%, while the tocopherol equivalents vary between about 20% and 30%.

When the RE and TE contents of the Carotino-based products are compared with those of conventionally baked products, the Carotino product contains 3 to 7 times more RE than the product without Carotino. Although the difference in TE for these products is not so large, the high tocotrienol content of Carotino is of significance, especially against the background of its more potent antioxidant properties when compared to tocopherols. In summary, it is evident that Carotino baking fat can make a significant contribution towards promoting public health. It not only has a great potential for alleviating vitamin A deficiency in developing countries, but it also can make a contribution towards combating degenerative diseases in developed countries. Carotino can thus make a significant contribution towards promoting public health worldwide.

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# Sugar fortification in Zambia

E. M. Besa

## Abstract

*Food fortification as a strategy for controlling vitamin A deficiency was mooted in Zambia way back when a technical committee was formed following a multisectoral workshop to explore possible food vehicles for vitamin A fortification. The choice of sugar as a vehicle was that it was centrally produced and therefore easy to subject to quality control. Moreover, more than 50% of the households consumed sugar. This initiative was explored with the private firm Zambia Sugar Plc, who saw it as a challenge for them to demonstrate their social responsibility to the public. This marked the beginning of a long-term partnership between the private and public sectors in Zambia. The initiative entailed embracing new technology, securing new equipment, and retraining and orienting staff from both the private and public sectors on the fortification process. Nothing was left to chance. While the orientations were ongoing, the legal framework to govern the standards of the new product was developed. These standards centered on its quality, safety, and labeling. The opinions of the beneficiaries of the fortification program were sought. Most welcomed the idea except for some concern about the added costs, possible toxicity, and accessibility of the new product. The education campaigns addressed these and other concerns.*

## Background

Food fortification as a strategy for controlling micronutrient deficiencies, such as vitamin A deficiency, was proposed in Zambia in 1996. A technical committee was formed following a multisectoral workshop to explore possible food vehicles for vitamin A fortification as a way to control micronutrient malnutrition in Zambia. Their deliberations and recommendations were based on the pioneering demonstration of Arroyave and Dary in Guatemala of the effectiveness of sugar as a vehicle for vitamin A on a national scale [1–4].

The most recent national statistics show an estimated under-five mortality rate in Zambia of 192 per 1,000 live births. Between 20% and 30% of hospital admissions are due to malnutrition. About 59% of Zambian children are stunted and 25% are underweight. Micronutrient malnutrition is also widespread in Zambia. A baseline survey carried out in 1997 revealed that the prevalence of vitamin A deficiency in children and in women of childbearing age was 65% and 22%, respectively (unpublished vitamin A survey 1997). These figures placed Zambia in the severe category according to the World Health Organization standards and cutoff points.

Evidence from other countries in similar situations confirms that vitamin A deficiency in young children is a cause of poor growth and increased morbidity and mortality from certain diseases, such as measles and diarrheal disease. In order to mitigate the effects of vitamin A deficiency, several interventions were introduced. These included vitamin A supplementation of children from 6 to 72 months of age and lactating women within 8 weeks of delivery, promotion of exclusive breastfeeding, and dietary diversification, which includes food fortification.

## Purpose and significance of fortifying sugar with vitamin A

The main purpose of fortifying household sugar was to increase the dietary intake of vitamin A in the Zambian population in order to reduce the mortality and morbidity associated with vitamin A deficiency. Supplement distribution was reaching only 28% of the target group. Fortification was therefore a complementary measure aimed at increasing the coverage of programs for improving the intake of vitamin A.

The Food Security, Health, and Nutrition Informa-

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tion System (FHANIS) placed sugar consumption at 72.1% through a survey in their sentinel points. The survey also indicated that almost all households consumed sugar at least once a week. This is one of the reasons used to justify sugar fortification.

Sugar was chosen as the fortification vehicle because it is centrally processed, making fortification and quality control easy; almost all Zambians consume it; almost all domestic sugar consumption needs are met by local production, with very little being imported; and the technology for fortification was available and could be adopted.

## Zambia Sugar Plc and sugar fortification

Zambia Sugar Plc is the largest sugar producer in the country. It was privatized in 1996, and in May 1998, as part of its responsibility, the company began to fortify all its domestically consumed sugar with vitamin A. The company saw this as an opportunity to sell the concept of sugar fortification and so was willing to invest in the sugar-fortification program. They also deemed it an opportunity to show their social responsibility to consumers. For them this was seen as something that would boost their corporate image.

After extensive consultations locally, Zambia Sugar Plc carried out a market survey to investigate whether sugar would still be acceptable to all consumers after fortification with vitamin A. The results showed that consumers were receptive to fortification as long as it did not negatively change the product.

Zambia Sugar Plc presented the following conditions to the partnership meetings before agreeing to fortify sugar: the costs of the initial fortification expenditure would be shared with the initiators of the project; initial training of technical staff had to be met by the initiators of the project; appropriate legislation had to be put in place banning all unfortified sugar from being displayed or sold in the country; and an education campaign was to be conducted by the fortification program while Zambia Sugar Plc would do the marketing of its branded product.

Just before implementation of fortification, Zambia Sugar Plc developed a new marketing strategy, including a new logo, new packaging, and an advertising campaign to improve the image of its product. The launch of the new logo coincided with the launch of the fortified sugar on May 15, 1998.

## Process of sugar fortification in Zambia

In order to address the public and private sector issues of fortification, a multidisciplinary fortification task force was established to work on the implementation, monitoring, and evaluation of the sugar-fortification exercise. This task force met frequently during the implementation of sugar fortification. Each task force member was assigned certain responsibilities, as follows:

» The National Food and Nutrition Commission coordinates all activities, serves as a source for technical and financial assistance, and conducts dietary and sugar consumption surveys.
» The Bureau of Standards and the Food and Drugs Control Laboratory sets up regulations and standards for fortified sugar and carries out routine checks on fortified sugar, including a Quality Assurance and Quantity Control program.
» The National Institute for Scientific and Industrial Research identifies equipment and chemical requirements, evaluates the shelf-life of vitamin A fortified sugar, and conducts dietary and food-consumption surveys.
» The Ministry of Health and Central Board of Health/Local Authorities carry out routine checks on fortified sugar for compliance and carry out Supervisory Quality Assurance Control programs.
» Zambia Sugar Plc manufactures and distributes the vitamin A fortified sugar.
» Cooperating partners—UNICEF, US Agency for International Development (OMNI/BASICS), JICA (Embassy of Japan), Society for Family Health (SFH), BASF, and Roche Pharmaceuticals—provide financial and technical support.
» Other institutions include the National Research Development Council (NRDC), Tropical Disease Research Centre (TDRC), and Zambia Revenue Authority (ZRA).

## Initial expenditure for sugar fortification

In line with the conditions of Zambia Sugar Plc for cost-sharing of the initial fortification expenditures, various partners helped. While Zambia Sugar Plc bought the fortificant at a cost of US$847,000, the US Agency of International Development (USAID) cleared the fortification for them free of value-added tax. USAID also purchased the precision feeders with spare parts and blenders. The Embassy of Japan (JICA) through the Society for Family Health provided spectrophotometers for both the sugar-production plant and the national laboratory. UNICEF provided the chemicals and glassware for laboratory analysis.

## Training and staff orientation

A team of five staff members were sponsored by USAID to attend a two-week orientation program in Guatemala, the model country for vitamin A fortification of sugar. The five members came from the National Food and Nutrition Commission, the National Food and Drugs Control Laboratory, the National Institute for Scientific and Industrial Research, and Zambia Sugar Plc (two members). They included a nutritionist, food technologists, and production staff. The training also provided an opportunity for the staff to review the technology and equipment used in fortification.

## Legal framework (revision of the Food and Drugs Act)

One of the conditions given by Zambia Sugar Plc for implementing the fortification of sugar was the revision of the Food and Drugs Act to ban nonfortified sugar from the Zambian market. Since the revision of the act would have taken too long a time, a Statutory Instrument on sugar was issued on December 19, 1998. The instrument makes sugar fortification with vitamin A mandatory, with a minimum level of 10 mg/kg. It also mandates the regulations for the quality, safety, and labeling standards for sugar.

### Quality and labeling standards

The quality standards include the definition that sugar shall mean refined, white, brown, yellow, or golden brown sugar. Apart from the general labeling requirements, the label shall contain the retinol content and the words “fortified with vitamin A” in bold letters.

### Packaging standards

Standards for packaging state that a nontoxic plastic material shall be used. The instrument also gives provisions for the standards for the fortificant and packaging and labeling of the vitamin A fortificant premix.

### Sugar fortification logo

A social-marketing company was hired to develop a logo that would give identity to the fortified sugar and that could be used as a marketing tool. The message on the logo, put on all domestically sold sugar packets, states that the sugar is fortified with vitamin A.

## Information, education, and communications

### Preliminary research

Prior to the fortification program, both Zambia Sugar Plc and the National Food and Nutrition Commission did studies to determine how the consumers would respond to the idea of sugar fortification. Generally it was welcome. The community perceived the addition of vitamin A to sugar as a way to get access to this important nutrient.

There was, however, a general concern from the public that the cost of adding vitamin A would increase the cost of sugar, thereby making it unavailable to the needy. A number of people were concerned that since they were already consuming foods with vitamins, adding vitamin A to sugar would make it toxic or they would consume too much vitamin A. These fears were allayed in discussion sessions.

In order to create community awareness of the new product, the task force agreed that Zambia Sugar Plc would be responsible for promoting the commodity and the National Food and Nutrition Commission would initiate campaigns explaining the health implications and benefits of consuming the fortified sugar in the households.

### Launching vitamin A–fortified sugar

The launch of the fortified sugar and the new logo took place on May 15, 1998, in the sugar production town in the south of the country. The Vice President of Zambia officiated at the ceremony, which was covered by television, radio, and newspaper reporters. A television documentary was also developed and aired. Radio and television spots in English and the seven local languages were developed and aired. Printed materials including leaflets and posters, T-shirts, and visor caps were produced and distributed. Community information sessions were conducted to discuss the new product and its benefits, including allaying the fears that had been raised.

Recently, laboratory technicians at both the government and the sugar company laboratories were retrained on standardized analytical methods. Health inspectors were retrained on sugar monitoring, with special emphasis on those at border areas.

## Challenges

Sugar has been fortified in Zambia for over two years. Although this action is laudable, it also has had some challenges.

### Cost

The most significant challenge was the cost of the fortificant. The prior calculation of the cost of producing fortified sugar estimated an increase of 1.4% over the actual cost. It was agreed therefore that an increment of 2% of the actual cost of sugar would cover the cost of fortification, including the annual household surveillance system.

Zambia Sugar Plc purchased the initial vitamin A fortificant at a cost of US$847,000. For the subsequent supplies, they requested that the Zambian government declare the fortificant duty free and zero rate it for the value-added-tax (VAT). A VAT zero rating was not possible because, according to the Zambian customs and exercise amendment Act No. 16 of 1996, vitamin A is a taxable commodity and is classified on the medical supply list. It is therefore taxable upon importation at 5% and 17.5% VAT.

Duty was temporarily suspended by importing the fortificant through the tax-free system of the USAID, one of the collaborators in the fortification process. Zambia Sugar Plc frequently noted that the fortificant was very expensive. They were also concerned about leveling the marketing field with regard to border controls, vitamin A dosage packaging, and quality.

#### Packaging

The initial research, including the study done by Zambia Sugar Plc, revealed that people normally buy small packages of sugar at any given time. The task force therefore recommended that 500 g packets be prepared. This would increase the accessibility of the product to households. Although the smaller packets were more costly, the company agreed to prepare them. However, they are rarely seen in the market. A request to produce even smaller packages was rejected by the company as not cost effective.

Most households cannot afford 2-kg packets and resort to purchasing repackaged ones (as small as 100 g) sold at street stalls. It is feared that the practice of repackaging the fortified sugar may result in large reductions in the amount of vitamin A in the sugar by the time it reaches the consumer. No shelf-life studies have been done in Zambia on vitamin A–fortified sugar. However, studies in other countries indicate that it can be stored for a period of one year with a minimum loss of vitamin A.

#### Monitoring and law enforcement

The Food and Drugs control laboratory has been responsible for quality control and quality assurance. They collected samples from the production plant every two weeks in order to ensure that the vitamin A levels in sugar were maintained. At some point in this monitoring, it was found that the vitamin A was not adhering well to the sugar. This was rectified as a result of discussions between the sugar company and the suppliers of the fortificant.

Enforcement of the Statutory Instrument on sugar took some time to implement. However, with retraining and orientation of authorized officials, the influx of unfortified sugar has been greatly reduced, especially in the southern part of the country bordering Zimbabwe. The challenge in law enforcement, however, is that the statutory instrument does not forbid unfortified sugar from being imported. This places a challenge on the authorities to maintain surveillance of the sugar in the market.

The high cost of living affects the purchasing power of many households. For sugar companies, it could lead to lower profit margins; for the program, it becomes difficult to control the repackaging of sugar into smaller packets, increasing the chance of loss of vitamin A and making the product more expensive for the consumer.

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# Fortification of common Nigerian food-cassava meals

Canice Chukwuemeka Asonye

## Abstract

*Cassava is the popular name of the tuberous plant* Manihot esculenta. *The tubers can be processed into products ranging from gari, akpu (fufu) or chikwangue, lafun (cassava flour), cassava cakes, and tapioca to alcoholic drinks (brukutu or cassava beer). The various types of cassava meals provide about 65% of total calorie intake of the poor of Nigeria and indeed of sub-Saharan Africa. Gari can be consumed in various forms, including flakes or made into a dough-like paste called eba and consumed with soup or sauce. Micronutrient deficiencies are common in areas where cassava is the main staple. Although supplementation is useful, it is not the solution to the elimination of micronutrient deficiency disorders in Africa because of numerous shortcomings, such as cost, transportation difficulties, and poor compliance. The simplest and most sustainable approach is fortification of staple foods with limiting micronutrients. Our pilot studies indicate that gari and lafun can be easily fortified with vitamin A and with B vitamins, as well as the minerals, iron, iodine, zinc, and calcium. It is our goal to develop feasible means of fortifying cassava for the benefit of the poor population of Nigeria and as an example for other cassava-consuming regions.*

## Introduction

Roots and tubers contribute more than 10% of the world's food needs, and more than one-half billion people worldwide depend on these cheap and vital sources of energy [1–3]. A perennial shrub of the family Euphorbiaceae is an important plant species commonly known as cassava (*Manihot esculenta*) [4]. Though produced mostly in developing countries, cassava is ubiquitous as a worldwide tropical staple, because it will grow in the harsh climatic conditions common to many poverty-stricken areas. It is therefore not surprising that hundreds of millions of Africans subsist on cassava products as their major staple food [5, 6].

Of the 120 million tons of cassava produced worldwide in 1980, more than 80% was consumed in Africa. Economic problems, political unrest, reduced soil fertility, drought, and the population explosion all have increased the need for cassava as a cheap, common, versatile crop that is resistant to adverse environmental factors, such as poor soil fertility, drought [7], and disease.

Cassava is versatile because it can be processed into a variety of food products, depending on need, economic factors, local custom and belief, and political situations. Moreover, it is a cheap and readily available energy resource year round. The population explosion, especially in Africa, has increased the demand for cassava products, because it is the most available dietary energy source. The leaves are also a good source of β-carotene [8].

The major countries producing large quantities of roots and tuber crops include Cameroon, Côte d'Ivoire, Ghana, Mozambique, Nigeria, Tanzania, Uganda, and Zaire. Nigeria, with a population of more than 120 million, is the most populous country in Africa and is the largest major producer of cassava and its products in Africa [9]. In 1998 alone, 16 million Nigerians, mostly children and mothers, suffered from vitamin A deficiency [10].

Cassava, the major staple among most Nigerians, has a low protein content [11], and subsisting on cassava alone could cause protein-energy malnutrition. Apart from the leaf, other parts of the plant have very little nutritional value other than supplying energy [12]. Although cassava leaves also contain cyanide, this should be no drawback to their consumption if they are cooked because it disappears during cooking and discharge of the cooking water [8]. However, the tedious and long processing required results in further losses of micronutrients. The cyanide content of most varieties of cassava poses a problem for its utilization [13–15]. There are number of ways in

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which the cyanide can be reduced to acceptable levels [16]. The postharvest vascular discoloration and tissue disintegration that virtually destroy cassava tubers within 24 hours of harvesting complicate its use. Moreover, prolonged consumption of cassava and its products without proper prior processing can result in the neurological disorder of tropical ataxic neuropathy [13, 17] as well as goiter and cretinism [18].

## Varieties of cassava products

There are various forms of cassava products that can be produced at home or industrially [3]. In Nigeria, the major varieties of cassava used are gari [19, 20], akpu or santana [21], which is another version of chikwangue, and cassava flour or lafun [22]. Cassava can be made into tapioca under several local or ethnic names. Cassava can also be used as a major component of composite flour for baking purposes [23]. It is also used to make an alcoholic beverage, brukutu or cassava beer.

## Processing and utilization as a prerequisite for cassava fortification

Because cassava tubers deteriorate within 24 hours of harvest, preparations for processing must be made before harvesting. There are numerous types of cassava products and processing methods, which are influenced by culture, custom, and environment. Most varieties of cassava cannot be consumed raw because of their high cyanide content. Fortunately, processing can reduce the cyanide content to acceptable levels.

The major reasons for processing include reduction of moisture content, reduction of cyanide content, generation of raw materials, and enhancement of taste and palatability [24]. After harvesting and peeling, the sequence of processing cassava in Nigeria is steeping in water plus fermentation (fufu); grating, pressing out water, fermentation, and frying (gari); or drying and milling (lafun or cassava flour).

## Methods

There are numerous processing techniques (fig. 1.) Processing is usually done on a small scale by individual families. But with increased demand, medium- and large-scale processing is becoming more common and presents improved opportunities for fortification. Our pilot studies show that gari is the most practical product for fortification. Not only is it the most consumed, but it is cheap, easy to prepare, and is palatable in taste and appearance. It is also the most suitable for mechanical processing in an industrial setup. Moreover, it is consumed regularly by both urban and rural populations. The fortificant mix can be added economically and thoroughly mixed during processing. Because the addition of retinyl palmitate results in a very faint yellow color to the previously white cassava flour (fufu, amala, etc.), nutritional education will be required to encourage acceptance of the fortified product.

### Sequence of pilot fortification

1. Cassava (gari) samples were collected from 100 processing locations nationwide.

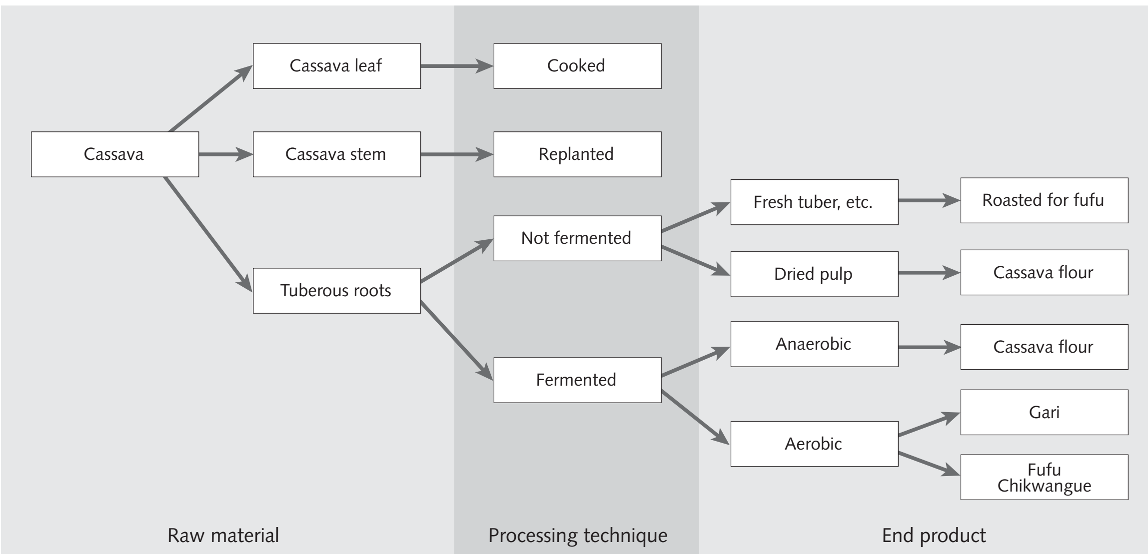


FIG. 1. Techniques of cassava processing

2. The following laboratory assays were performed:
   (i) Microbial load.
   (ii) Cyanide content (using the Ikediobi et al. method [19])
   (iii) Calorimetry
   (iv) Assay for environmental pollutants
3. Laboratory fortification
4. Packaging
5. Assessment of nutritional value by biochemical methods in periods of one, three, and six months.

### Dosages used

*Vitamins:* vitamin A, 1 mg RE/kg; vitamin $B_1$, 1.5 mg thiamine (as thiamine ion); vitamin $B_2$, 1.8 mg riboflavin; vitamin $B_3$, 20 mg niacin equivalent; vitamin $B_6$, 2.0 mg pyrodoxin (as pyrodoxal); folic acid, 10 mg folate; vitamin $B_5$,10 mg panthothenic acid; vitamin C, 80 mg ascorbic acid; vitamin E, 12 mg TE (tocopherol equivalent). *Minerals:* iron, 12 mg/day (no consumption could exceed this dosage); iodine, 150 mg/day; zinc, 10 mg/day.

## Results

Nutritional value and losses in appearance and texture were assessed on day 1 and at 1, 2, 4, 12, and 24 weeks. Under ambient storage conditions, there was an 80% retention of most of the micronutrients. There were no significant changes in appearance, stability, and other features, such as acceptability.

## Discussion

Akinrele [25], who initiated fortification studies on cassava, stated that the nutritional value of cassava could be improved by enrichment with proteins, vitamins, and minerals. But this concept of fortification used an enhancement process with groundnut flour, soybean flour, and sesame flour. The recipe contained 70 parts of full-fat soy flour, 20 parts whole-fat sesame flour, 5 parts full-fat groundnut flour, and 5 parts dried yeast powder, which produced a biological value of 78. The recipe is quite elaborate and has limitations. This concept was not further pursued.

Monosodium glutamate (MSG) was industrially fortified with vitamin A and other micronutrients but was vehemently rejected by rural and urban women, the major hindrance being inadequate publicity.

Some decades ago the Federal Government of Nigeria promulgated laws on wheat and maize fortification, but nothing has been done. With increasing poverty, there is also a commensurate increase in vitamin A deficiency [26], which is further heightened by sociopolitical and environmental factors.

## Conclusions

Cassava products, especially gari, have become major sources of energy for the people of sub-Saharan Africa. Among the major staples of the world, cassava has one of the lowest levels of nutritional value, but due to circumstances beyond our control, it has become a necessity for the people in this geographical location. Gari, for example is common, regular, very cheap, bioavailable, and stable in color, taste, and texture. It is also fast to prepare, available year-round, and has great potential for fortification.

Sub-Saharan Africa faces serious economic and agricultural problems. The 1980s ushered in severe food emergencies. Africa's food problems are not a set of anomalies but are the very logical consequence of a series of structural, economic, and agricultural problems [27]. We therefore need to start somewhere to tackle these problems. The easiest, most sustainable, and cheapest means is by food fortification.

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# Food-fortification program in Morocco

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## Abstract

*The Kingdom of Morocco launched the flour and oil fortification stage of its National Micronutrient Program in December 2000. The vitamin A (oil) and iron (flour) fortification components of the program are based on the 1994 and 1996 national and regional surveys, which showed that 38% and 40.6% of children under five years of age, respectively, were iron and vitamin A deficient. Morocco is following the example of many countries that fortify their salt with iodine and flour with iron, folate, and/or B vitamins. In addition, it is innovative in including vitamin A–fortified oil in its pioneering fortification program, the first in North Africa. This paper concerns the advocacy and consensus-building components in support of iron, vitamin B, and folate-fortified flour and for vitamin A–fortified oil (iodized salt began in 1996). As part of its efforts to implement a sustainable food-fortification strategy, the Ministry of Health has already launched a series of activities. The selection of flour and oil to fortify is based on food-consumption patterns. Hydrogenated cooking oil was identified as a good vehicle for fortification because it is centrally processed and over 90% of households use it daily for a variety of cooking purposes. Oil is an excellent fortification vehicle for vitamin A because it is a fat-soluble vitamin. Flour was identified as a good vehicle for iron fortification because 95% of households use it as the main ingredient in bread. The entire population consumes centrally processed flour, even households that also use homemade flour. This is because about one million metric tons of centrally processed flour are subsidized by the Government, at a savings of at least 50% compared with nonsubsidized flour. One innovation of the program is to launch fortification for the general public at the beginning of Ramadan, a month-long religious period, when oil and flour consumption increase significantly.*

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## Nutritional situation in Morocco

Morocco is a North African country with about 28 million people, half of whom reside in rural communities. Illiteracy is high, mainly among women in rural areas (table 1)[1]. It is a developing country with many nutritional problems similar to those in many other countries in the same economic situation. Results from national surveys conducted in 1993 showed that 22% of children aged between 6 and 12 years had a goiter (iodine deficiency), with a high prevalence in rural and mountainous areas [2]. Morocco launched a children's supplementation strategy that established the salt-fortification program in 1995.

The 1996 regional survey on vitamin A deficiency showed that 40.6% of children under six years old had serum retinol levels under 200 μg/L. The prevalence was even higher in rural and mountainous regions. A

TABLE 1. Trends of sociodemographic indicators in Morocco

| Indicator | 1970 | 1980 | 1994 | 1999 |
|---|---|---|---|---|
| Population (millions) | 15 | 19.3 | 25.9 | 28.2 |
| Urban population (%) | 34.5 | 41.1 | 51.2 | 54.4 |
| Infant mortality (000s) | 91 | 73 | 57.3 | 36.6 |
| Fertility rate (000s) | 7.4 | 5.5 | 3.3 | 3 |
| Life expectancy (yrs) | — | 65 | 67.9 | 69.5 |
| Illiteracy (%) | 75 | 65 | 55 | 47 |
| Per capita domestic product (US$) | — | — | 1,220 | 2,010 |

Source: Ref. 12.

low consumption of vitamin A–rich food is the most important risk factor implicated in the development of vitamin A deficiency in Morocco [3]. In 1998, the Ministry of Health started a vitamin A supplementation program for children under two years old during the immunization campaign. A 1994 national survey on anemia in Morocco [4] reported anemia to be a serious public health problem, with more than one-third of women and children under five anemic, and about 45.5% of pregnant women iron deficient. A national program was started in 1998 to supplement all pregnant women. In addition, a 1997 national survey on mother and child health reported that 24.1% of children were stunted [5].

## Micronutrient National Committee task

The results from these surveys brought out some factors associated with these public health problems, e.g., an unbalanced diet, women's illiteracy, poor environmental conditions, and a weak health communication system. Following completion of the situation analysis, the Ministry of Health established a global program to fight malnutrition in Morocco. A Micronutrient National Committee was set up to include researchers, health workers, policy makers, industrialists, producers, pharmaceutical companies, national and international nongovernmental organizations, and a regulatory board.

The task of the Micronutrient National Committee was to establish strategies to eliminate iodine deficiency and vitamin A deficiency by 2004 and to reduce the prevalence of anemia to one-third its initial level. The national committee has many programs concerning supplementation, education, and fortification.

Morocco started to fortify salt with iodine in 1995. However, the program was not fully successful, since iodine deficiency problems are still present in many regions and fortified salt does not reach the target population. The failure of the salt-iodization program was due to the presence of both iodized and noniodized salt on the market, and to a poor marketing and promotional strategy. The committee learned from the iodized salt experience and developed a global program for all fortified foods with an important promotional strategy. The objective of this paper is to describe the fortification program in Morocco, especially oil and flour fortification

## National committee activities

The National Micronutrient Committee set up some activities in fortification programs. The following were the most important of these activities.

In collaboration with the commercial market strategies of the USAID project, the committee reviewed existing studies on food-consumption patterns, including levels and trends to identify which food should be fortified and to define the viability of fortified foods and develop the most effective marketing and promotional strategies for them.

The committee sponsored a qualitative survey in six regions of the country, including 30 focus groups that included men and women from all socioeconomic classes. The objectives of this survey were to determine attitudes and knowledge of the population towards fortified foods and to define obstacles and taboos that could impede this program.

The committee selected an agency to use the results of these studies to prepare a generic logo for all fortified food and to design appropriate mass-media materials that will be pretested before production

The committee also assigned two national laboratories to work on and develop standards for flour and oil fortification, and initiate feasibility studies and tests for vitamin A fortified oil.

## Research study findings

The synthesis study using the results from the national household income and expenditure survey of 1988–89 on food-consumption patterns demonstrated that cereals, oil, and refined sugar provide about 80% of daily energy intake. Cereals provide more than 50% of energy in rural areas and are by far the most important energy-giving product (fig. 1). In addition, a regional food-frequency consumption survey on 1,500 women and 500 children under five years old revealed that 89% of the studied population consume the three staple foods flour, oil, and refined sugar at least once a day (fig. 2) [6]. These results suggest oil, flour, and refined sugar as potential staple foods to be fortified.

### Flour fortification

Bread baked from wheat flour by women in the household is the staple food on the table of each Moroccan household at least three times a day. The daily individual consumption of bread is about 500 g [7]. The flour will be fortified with reduced iron, folate, and B vitamins. People can buy grain at the grain market and have it ground at the nearest local mill, or they can buy commercial flour.

In Morocco, there are two sectors in the flour market, the formal and the informal sector [8]. The formal sector is made up of 140 industrial millers grouped in a national federation of millers. This sector supports the flour-fortification program. The national production is about 35 million quintals per year; 32% of the national production of industrial flour is subsidized by the government. The informal or small-

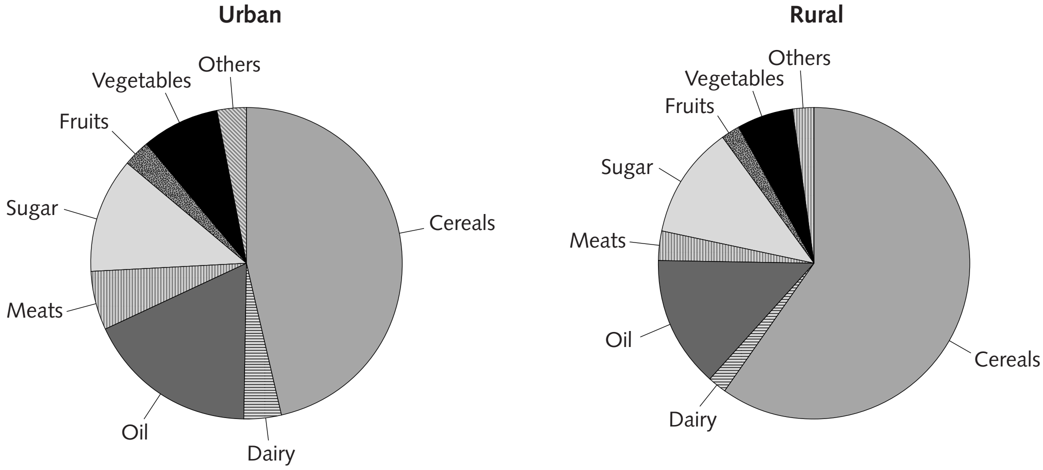


FIG. 1. Diet composition of the Moroccan population in urban and rural areas

scale sector, made up of 9,000 small artisan mills, is very important. The rural customers buy grain or use their own grain production and take it to the nearest small mill to be milled into flour [9]. The main question asked by the national micronutrient committee was: Does the target population use sufficient commercial flour that it should it be fortified?

The results from national surveys on household income and expenditures done in 1990–91 and 1998–99 [10] shed some light on this question. Studies on trends of individual expenses for grains and industrial flour in terms of percentage of total cereal expenses in 1990–91 and in 1998–99 (fig. 3) showed that in urban areas in 1998–99, the purchase of grain decreased from the 1990–91 level, and expenses for industrial flour remained constant. In rural areas, while grain expenses decreased significantly, the purchase of industrial flour increased.

The results of the survey also indicated that in rural areas more than 60% of the total cereal budget was used for the purchase of industrial flour, mainly subsidized flour. Thus, the rural population uses both industrial and locally milled flour to make bread. These changes in cereal consumption patterns are due to two main factors: frequent droughts in Morocco, almost one year out of two, and the existence of subsidized flour, which is actually less expensive than grain.

These results point out the importance of economic factors for the viability and success of fortified flour; indeed, the availability of subsidized flour is an important factor for the viability of the flour-fortification program.

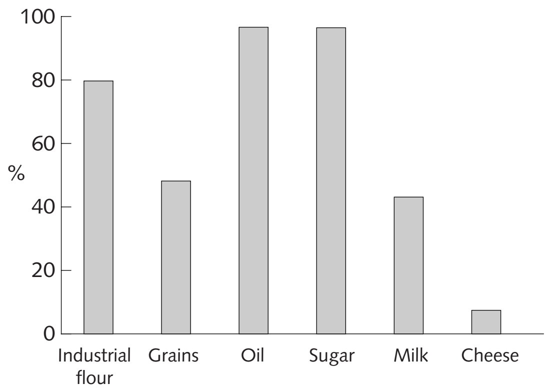


FIG. 2. Food-frequency consumption in Morocco: percentage of population consuming foods at least once a day

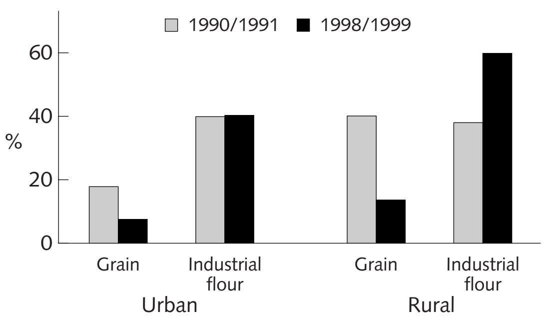


FIG. 3. Trends of individual expenses in grain and industrial flour (% of total cereal expense)

### Oil fortification

Oil was chosen to be fortified with vitamin A. In Morocco, the main oil consumed is soybean oil (260 million kilograms), 70% of which is imported. An association includes the six large producers who control close to 80% of the total oil market in Morocco. Fifteen percent of this market is olive oil.

The consumption of oil is close to 13 kg per person per year, a much higher level than that in many countries in the Asian region.* The government strictly controls the oil market and determines and enforces the price of oil. Oil producers supported the oil-fortification program, especially after the liberalization of controls on the oil industry in Morocco in October 2000. Fortification will be used by the industry as a marketing strategy, and thus will be advantageous for them.

The cost of fortification for the customers is very low. Oil producers are committed to pay all expenses for the fortification technology, and the national committee is committed to support the advertising materials for fortified oil. Fortification will be centrally monitored by a selected laboratory. The generic logo and advertising spots will be pretested before use. Fortified flour will be pretested in some selected cities before national distribution. Fortified oil will be available at the end of 2001.

* Verges A. Feasibility of oil fortification with vitamin A in Morocco. Consultant report to the Micronutrient Initiative, Ottawa, Canada, 2001.

## Conclusions

Morocco has made considerable progress in developing a program to fortify flour and oil with nutrients. Positive factors that have contributed to this include the establishment of a National Micronutrient Committee and a multidisciplinary control board, strong mass-media support, and the goodwill of producers. However, there are negative factors that can impede the progress and sustainability of food fortification in Morocco. These include the dual nature of the oil market, the sustainability of subsidized flour, and the division of flour production between large-scale commercial and small local mills.

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# Public-private partnerships for combating micronutrient malnutrition

Mickey Chopra

## Abstract

*Micronutrient malnutrition remains an important public health problem. Public-private partnerships have been promoted as a cornerstone in combating micronutrient malnutrition. Most developing countries are struggling to establish successful partnerships. Traditionally, the difficulties have been put down to misunderstandings due to poor communication. However, this paper will argue that more fundamental issues need to be addressed before the widespread acceptance of public-private partnerships can be achieved. This paper outlines the recent impetus towards public-private partnerships in nutrition and looks at some models of partnerships. The potential benefits of public-private partnerships are examined for three different role-players: the United Nations, recipient countries, and private business. Thorny issues for public-private partnerships, such as values, governance, resources, and equity, are explored. There are fundamental questions around these issues that need to be addressed before public-private partnerships can be promoted as the solution to the elimination of micronutrient malnutrition.*

## Introduction

It has been estimated that over a billion people suffer from some form of micronutrient deficiency. Nearly all of these people are from the most disadvantaged sectors of the world. A review by International Food Policy Research Institute (IFPRI) concluded that the Green Revolution, while achieving widespread caloric success, has not led to concomitant decreases in maternal anemia and childhood micronutrient deficiencies. The higher-yielding strains of wheat and rice, which are replete with more energy-rich macronutrients, did not provide comparable increases in the micronutrients [1]. Despite some impressive gains made by the international nutrition community, especially with regard to vitamin A supplementation and salt fortification, we are still far short of the targets set by international agencies at the beginning of the 1990s, and there is a concern that further progress is proving difficult.

Both supplementation and fortification approaches require some dialogue and, potentially, partnerships between the public and private sectors. This is in keeping with a trend in international public health that has recently witnessed the high-profile establishment of public-private partnerships to combat public health problems such as malaria (Malaria Vaccine Initiative), AIDS vaccine (International Aids Vaccine Initiative, IAVI), and child health (Bill and Melinda Gates's Children Vaccine Program). For many, establishing public-private partnerships to provide supplements and fortified foods is the most important strategy towards achieving the desired reductions in micronutrient malnutrition. However, many key questions remain unresolved and have retarded progress towards the elimination of micronutrient malnutrition through public-private partnerships. This was highlighted at a recent meeting to discuss the role of public-private partnership in combating micronutrient malnutrition convened by Partnerships Against Micronutrient Malnutrition (PAMM) in June 1999. There was reluctance by key public role-players to participate in an initiative that embraced partnerships with the private sector without first addressing fundamental issues such as the roles and responsibilities of the public and private sectors, the framework for any potential partnerships, the potential benefits and costs to the partners, and issues around governance and equity within the partnerships.

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Mention of the names of firms and commercial products does not imply endorsement by the United Nations University.

## Why have public-private partnerships become so important?

### Size and nature of the problem

The sheer enormity of the micronutrient malnutrition problem, with nearly one-quarter of the world's population affected, makes it difficult for public agencies alone to respond. Furthermore, the increased globalization of food distribution and the concomitant rise in the role of large multinational companies in influencing food consumption in many developing countries has meant that the private sector is an important player in any food-policy decisions.

### Interdependence

The last point highlights another facet of recent globalization: the greater interdependence of the two sectors. The ability of the public sector to improve micronutrient malnutrition status is inextricably linked to the decision and behavior of the private sectors vis-à-vis pricing and availability of supplements and fortified food. This in turn depends upon the signals sent by the major public-sector players to the private sector (legislative framework, effective monitoring, tax incentives, etc.).

### Resources

The gradual decline in direct funding for UN agencies and the ideological shift in the 1980s towards decreased public-sector budgets has resulted in a greater dependency on private funding and resources to overcome many of the major international public health problems [2]. The increasing cost and complexities of many of the solutions to these problems has also driven many UN organizations and governments into forming partnerships with the private sector (International AIDS Vaccine Initiative, Malaria Vaccine Initiative).

### New public health

The work of researchers such as Robert Putnam [3] and Richard Wilkinson [4] has highlighted the importance of a strong civil society for improving health, welfare, and economic growth in a society. This has been incorporated into the new public health paradigm that seeks to build partnerships at a community and national level to tackle fundamental public health problems. Thus far this has not traditionally included the private sector. However, the actions of an increasing number of civil organizations are forcing large corporations to accept greater social responsibility. The use of new technology and mass communication has meant that the multinational corporations have to be more responsive to a more informed global civil society. The campaign against the baby milk formula companies is one of the most successful examples of this. Partnerships between multinational organizations and the public sector in tackling high-profile public health problems can help to ameliorate some of this opposition.

### Political ideology

The last 10 years has witnessed the retreat of the neoliberal ideological reliance upon an unrestrained market as the panacea. Similarly, the collapse of the state capitalist economies of Eastern Europe has sullied the reputation of state-led interventions. On both sides of the Atlantic, a new "Third Way" is being propounded which has at its heart a corporatist philosophy. Private-public partnerships in combating micronutrient malnutrition are very much in line with this new political approach.

## Models of partnerships

A number of different models of public-private partnerships have emerged, which differ in their scope and form. Buse and Walt [5] have differentiated three different types of partnerships.

*Product-based partnerships.* These consist mainly of drug donation programs (e.g., AmBisome for the treatment of leishmaniasis). These public-private partnerships are usually initiated by the private sector who may seek short-term objectives such as establishing national and global political contacts but are also probably seeking to establish their reputations as ethically oriented.

*Product-development partnerships.* Most of these products are perceived by the public sector as worthy of societal investment, but the market fails to allocate resources to their research and development because of a perception of poor returns from such products. For instance, the large International Aids Vaccine Initiative and Malaria Vaccine partnerships have arisen because of uncertainty in the private sector about the market for such a vaccine that would offset its development costs. To a limited extent, the development and use of fortificants (i.e., the double fortification of salt) in a number of countries falls under this type of partnership.

*Systems- and issues-based partnerships.* A number of high-profile, issues-based public-private partnerships have been initiated to harmonize or bring strategic consistency among the approaches of various actors to single diseases as well as to raise their profile on the health policy agenda. The International Vitamin A Consultative Group (IVACG) is an example of this.

Although the above classifications capture the types of models, Mitchell-Weaver and Manning's [6] classification stresses the organizational form that partnerships can take. Three models are suggested, which differ according to which private interests "participate in the strategic-level decision-making in the public interest."

*Elite committee model.* Negotiation occurs between relatively equal partners to arrive at a consensus decision. This is used to influence the behavior of their organization in order to achieve the partnership goals. This is the predominant model in most developing countries in which a dialogue between food producers and multinational food companies has sometimes been initiated around food fortification. In a few countries, such as the Philippines, this has resulted in the successful fortification of a food vehicle [7].

*Nongovernmental organization model.* The public sector provides the financial, organizational, or material resources for the private sector to carry out the public program (e.g., vitamin A supplementation program in Zimbabwe).

*Quasi-public authority model.* A hybrid organization with both private and public representation is created to allow the easy entry of public goods or services by the private sector. The creation of a sugar-fortification council in Guatemala is such an example.

Within the micronutrient field, most of the attention has been on the role of public-private partnerships in fortification of key foods to combat micronutrient malnutrition in developing countries. Nongovernmental organizations such as the Micronutrient Initiative and aid organizations such as the US Agency for International Development have very actively promoted the role of the private sector in fortifying key food vehicles in developing countries. Most of these partnerships have been at the national level; the most conspicuous examples are the fortification of sugar in Guatemala and Zambia and the fortification of a brand of margarine in the Philippines [8].

What is missing in the micronutrient malnutrition literature is a more detailed analysis of the forms of public-private partnerships dealing with micronutrient malnutrition in developing countries. Which forms have been most successful and sustainable? Who are the key partners? Who should take the lead in forming such partnerships? To what circumstances are the different forms most suited? These are all questions that need to be more fully explored.

TABLE 1. Advantages of private-public partnerships for the public and private sectors

| Advantages for the public sector | Advantages for the private sector |
|---|---|
| Additional resources | Increased influence in the global arena |
| Increased legitimacy | Increased influence at the national level |
| Increased efficiency | Direct financial benefits |
| Attaining public health goals | Increased authority and added legitimacy |

## Obstacles to public-private partnership in micronutrient malnutrition

Despite the advantages outlined in table 1 and the considerable effort and resources that have been expended in promoting public-private partnership for fortification in a number of developing countries, examples of successful fortification programs in developing countries, with the exception of salt iodization and some cereal flour-fortification programs remain few. The technology, choice of food vehicles, and cost of fortification are not major obstacles to fortification. A meeting of public and private role-players in micronutrient malnutrition identified a "communication gap" as the most important reason for the failure of fortification to succeed. "The communication gap means that industry leaders have not been challenged to respond to micronutrient malnutrition.... The gap also means public leaders often do not have input from the business community" [9].

Although improved communication between the sectors is needed, the lack of communication does not fully explain the delay in the formation of successful partnerships. There are other issues that need to be considered: values, governance, resources, and equity.

### Values

Zigmut Bauman, a leading sociologist of globalization, highlighted the contradictory impact of globalization on ethical values [10]. On the one hand, globalization presents the opportunity for a common value system that promotes democracy, social equity, and human rights. On the other hand, it can also lead to a growth of inequity, a rise in polarizing nationalistic values, and the predominance of the individualistic market-dominated conception of human rights. An increasingly important role being played by multilateral organizations, such as the United Nations, is one of promoting the former, while it may be argued that many multinational corporations are actively contributing to the latter. In this context, is it possible to have partnerships based upon shared values?

This issue is especially pertinent in the nutrition field. Many in the public nutrition sector have witnessed and fought against the powerful profit impulse of the formula food companies. The recent admission of guilt with respect to price-fixing of vitamin supplements by Roche highlights the difficulty of entering into partnerships with private companies whose values are different from those of the public sector.

## Governance

For the sake of brevity, governance will be considered under the following three themes: representation, accountability, and setting of standards.

### *Representation*

Related to the issue of differing values is the question of whose values and interests will be represented? No health or nutrition global public-private partnership can claim near universal membership of nation-states (which would probably be unrealistic anyway), but more importantly, few partnerships include representation from low-income countries [5]. Even at a regional or national level, many public-private partnerships for fortification rarely include consumer groups or other community-based nongovernmental organizations. The policy agenda in these countries is thus further controlled by the elite and perhaps has more influence from the private sector than before.

### *Accountability*

The large-scale projects undertaken in many countries by public-private partnerships make it difficult for the partners to be accountable directly to the beneficiaries. More seriously, there have been no mechanisms developed to sanction negligent partners. Once again, the experience of dealing with formula food and large pharmaceutical companies is a sobering one. In the field of micronutrient fortification and supplementation, it has been the experience of a number of countries that it is the state, through legislation and public education, which has to ensure the accountability of the private partners. Ironically, this undermines one of the main motivations for the promotion of public-private partnerships: a desire to reduce the powers and role of the state. If public bodies have become publicly involved in partnerships with private organizations, to what extent will this stifle and modify their role as independent advocates for public health, especially when their "partners" are the perpetrators?

### *Standards*

One of the paradoxes of the freer movement of capital in the new global economy is the need for large companies to have global rules and standards to protect their investments and markets from local producers. The World Health Organization has traditionally been the body responsible for performing a global normative function. However, as their technical committees increasingly enter into partnerships with the private sector, there is a danger that the norms and standards will start to favor their private partners. Muraskin [11] argued that this was the case with the Expert Committee on Biologicals, which sets the standards on vaccines. The standard was set so high that it placed developing-country industries at a disadvantage.

In the field of nutrition, the Codex Alimentarius Commission, an international body with representation from both private and public sectors, has responsibility for setting food standards and quality. Further study of the Codex highlights some of the dangers of pursuing the ideal of a public-private partnership without careful attention to its form and governance. On its committees there are 26 representatives from public-interest groups compared with 662 industry representatives. Nestlé, the largest food company in the world, sent over 30 representatives, more than most countries. Only 7% and 10% of representatives came from Africa and Latin America, respectively, compared with more than 60% from Europe and North America (North America sent almost twice as many representatives as all of Africa). Of the participants on the working group on standards for food additives and contaminants, 39% represented transnational corporations of industry federations, including 61 representatives from the largest food and agrochemical companies in the world [12].

## Resources

A major motivation for the promotion of public-private partnerships has been the argument that they have the potential to bring in large resources to tackle public health problems. Although there has been a great deal of publicity concerning the large sums that have been brought into health by the private sector through public-private partnerships, their contribution may be relatively modest. First, any contribution is tax deductible. Second, the contribution might only be a small part of the profit gained from a particular project (e.g., the cost of the Bridging the Gap project funded by Bristol Myers Squib is 0.1% of their annual sales). Finally, the relative contribution of the public sector may account for most of the investment [5].

This final point is especially relevant in the micronutrient malnutrition field. Experiences from nearly all successful public-private partnerships in fortification have all relied upon a significant investment by the public sector in public awareness campaigns, safety regulations and monitoring, training of health workers, reduced import tariffs, etc. Furthermore, in some poorer countries there is a danger that the pressure to enter into public-private partnerships for fortification may be at the expense of local priorities.

### Equity

Within the micronutrient field, the fortification of processed foods holds the greatest promise for public-private partnerships. One of the concerns of a growing number of public health workers in developing countries is the increasing "westernization" of the diet of large segments of the population in developing countries [13]. The growing penetration of multinational corporations into developing countries with energy-rich processed foods is usurping traditional diets. The increased intake in fats and sugars is already manifesting itself in the rise of noncommunicable diseases in most developing countries (and at a much faster rate than developed countries did in the past)[14]. The increased globalization of food production is also seriously undermining the household food security of many of the rural poor. Large factory farms are drawing in farmers and at the same time buying out land. There is a danger that the further endorsement of processed food products by respected international public agencies will accelerate this process. Targeting processed foods as food vehicles for fortification would mostly benefit the urban population that has ready access to such foods, thus exacerbating already wide inequalities between urban and rural populations in developing countries.

## Conclusions

This paper has outlined the almost irresistible drive towards private-public partnerships in international health. A number of factors have facilitated public-private partnerships, and both the private and the public sector stand to gain a number of advantages from forming partnerships. The sheer size and importance of micronutrient malnutrition makes public-private partnerships an important part of the solution.

Poor communication between the two sectors has been raised as the main cause of the relative paucity of public-private partnerships in combating micronutrient malnutrition in developing countries. However, this paper has raised a number of additional questions that need to be addressed. These include limited representation of developing countries on international bodies designed to set standards for food safety, the substantial public resources that public-private partnerships can consume, the potential for further exacerbating inequities, and the substantial differences in values and principles between the public sector and some of the leading pharmaceutical and food companies. These are some of the concerns that the public sector has vis-à-vis public-private partnerships in the micronutrient field. Issues of differences in principles and values, and governance need to be exposed and discussed.

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# Food-based strategies: Can they play a role in international development?

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## Abstract

*Over the past two decades, the definition of poverty has been broadened to include social, economic, environmental, and human development dimensions. In line with this shift of thinking, all countries committed at the 2000 G-8 Summit in Okinawa to achieve the International Development Goals to alleviate poverty by 2015. Development organizations, such as the international development banks, have committed to provide support to countries to reach the International Development Goals, including two goals that specify significant reductions of child and maternal mortality. There is significant evidence that malnutrition, particularly micronutrient malnutrition, contributes to child mortality and growing evidence that malnutrition plays a similar role in maternal mortality. Inadequate dietary intake is an immediate cause of malnutrition, and thus it seems logical that food and agriculture activities could contribute to improvements in nutrition and micronutrient status. Global availability of cereals is adequate, but the rate of undernourishment (inadequate caloric intake) is still high, and child undernutrition still persists in many countries, suggesting that distribution of food is poor. Global availability of noncereal foods, such as animal and horticulture foods, is well below global requirements. Consequently, micronutrient deficiencies, which result mainly from inadequate intake of micronutrient-rich foods, particularly animal foods, are prevalent in most developing countries. Food-based strategies, such as home gardening, small-animal husbandry, poultry, and social marketing, lead to better food production, food consumption, and overall food security. Examining the relative contribution of the determinants of food security—availability, accessibility and consumption/choice—in a given setting provides insight into how the nutrition benefits from food-based strategies, as well as from macro food policies, might be maximized. When implemented in this context, food-based strategies can help countries achieve several of the International Development Goals.*

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## Evolution of the definition of poverty and the international development agenda

Over the past two decades, there has been a shift in thinking regarding the goals of international development. This change was stimulated in part by Sen, Dreze, Schultz, and others, who introduced the concept that poverty goes beyond the traditional definition of lack of income to encompass economic, social, and governance dimensions [1–3]. Sen further argues that the alleviation of poverty also requires better opportunities and freedoms for the poor [4]. This thinking was the basis for the development of the human development index (combining life expectancy, adult literacy, and income to reflect health, education, and resources, respectively), promoted by the United Nations Development Programme to rank a country's level of development. Although historically the programs and policies of the international development banks have emphasized economic growth, Sen and others influenced the strategic thinking and policies of these organizations at the international level as well as the process and content of their programs at the country level. Motivated by the broader definition of poverty and refocus in development, leaders of all countries agreed on International Development Goals to alleviate poverty by 2015 at the G-8 Summit in Okinawa in 2000. These goals combine economic growth, human development, environmental management, and increased participation of women [5, 6]. Measurement of poverty is beyond the scope of this paper, but it is an essential component of global as well as country-specific poverty alleviation strategies [7, 8].

## Mortality reduction and nutrition

Two of the seven International Development Goals concern mortality: reduction in the mortality rates for infants and children less than five years of age by two-thirds, and reduction of the maternal mortality ratio by three-fourths. A model showing the links between mortality, nutrition, and food is presented in figure 1. The majority of mortality in children is attributed to preventable diseases, such as acute respiratory infections, diarrhea, measles, and malaria [9, 10]. The main causes of maternal death are hemorrhage, eclampsia, and postpartum sepsis [11]. In this model, malnutrition, a main underlying cause of disease, is characterized by two arms: micronutrient malnutrition and energy or protein-energy malnutrition. The contribution of protein-energy malnutrition, even moderate or mild malnutrition, to child mortality has been established [12], although this contribution may not be equivalent for all diseases [13].

There is strong evidence that micronutrient deficiencies are associated with increased risk of child and maternal mortality. In eight studies reviewed by Beaton et al. [14], the average reduction in child mortality was 23% with weekly or large biannual vitamin A supplementation. Although more research is needed, results from a study in Nepal showed that vitamin A supplementation among deficient populations during pregnancy may reduce maternal mortality [15]. Other nutrients, such as iron and zinc, are essential for

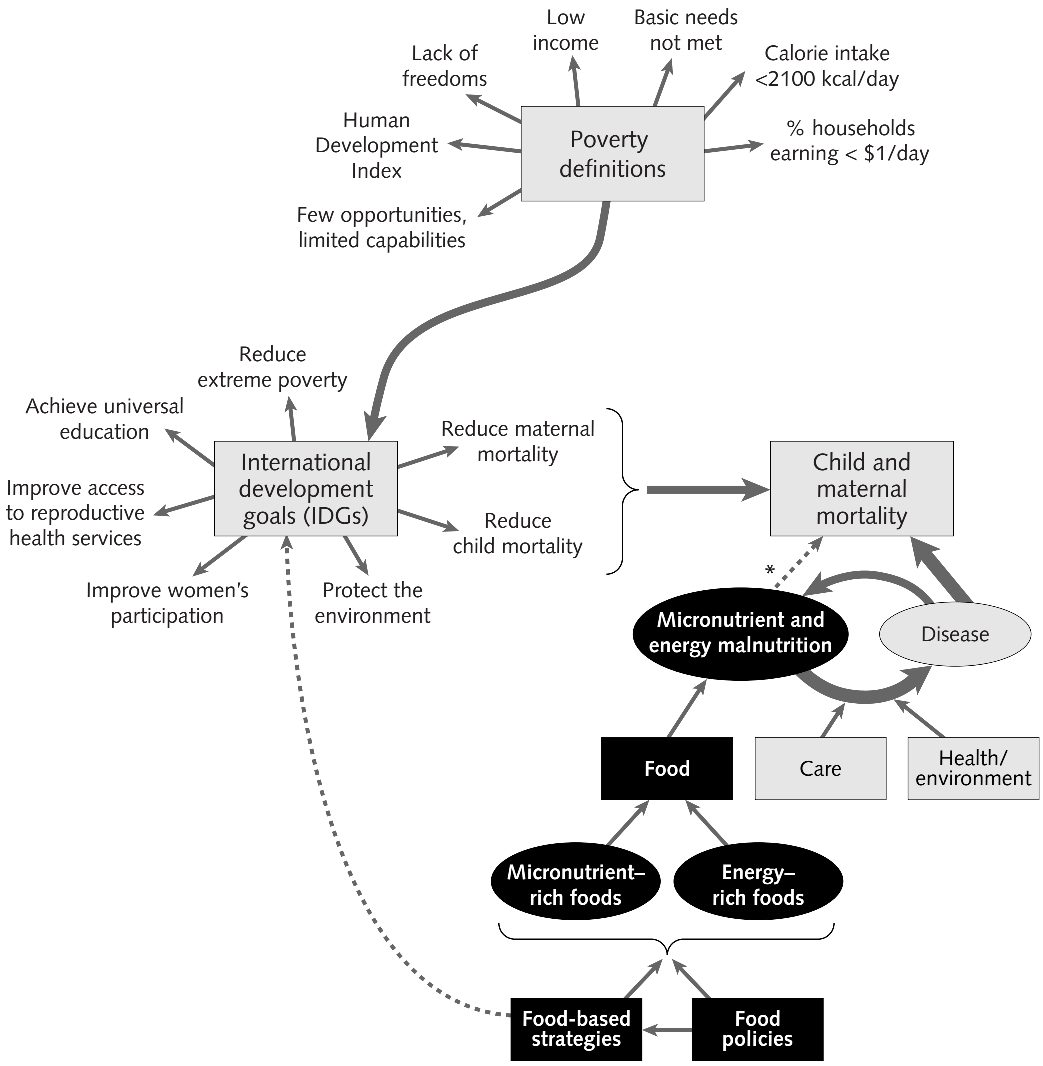


FIG. 1. Conceptual model of the links between poverty, nutrition, and food-based strategies.

* Malnutrition is a major contributing cause of mortality and acts by influencing susceptibility to disease and the severity and duration of disease

many biological functions and for host immunity, and therefore deficiencies in these nutrients influence child and maternal mortality [16–18]. Although the two forms of malnutrition often coexist and are interrelated in etiology, the quality of the diet (adequacy in terms of vitamins and minerals) is better reflected in micronutrient status, whereas changes in diet quantity are more likely to be reflected in anthropometry, particularly maternal body-mass index [16, 19].

## Avenues to improve nutrition and micronutrient status

This new perspective that improvement in nutrition and micronutrient status can help countries reach the International Development Goals for mortality should be translated into policies and programs at the international, national, and community levels [20]. The multidimensional aspects of malnutrition, starting from its etiology, suggest that different sectoral approaches can be employed to improve micronutrient status. For instance, micronutrient status can be improved through supplements (iron tablets, vitamin A capsules). Although the incorporation of supplementation into health programs appears to be straightforward, only high-dose vitamin A capsule supplementation programs, which are administered biannually through campaigns, and iron supplementation during pregnancy have had more than limited success. Other programs for iron supplementation have not been effectively implemented [21]. More is now being done to make such programs effective, but even so, supplementation alone is not a sustainable solution to micronutrient deficiencies in many developing countries.

Food fortification can also increase micronutrient intake and has been successful in the developed world and in a number of developing countries, particularly in Latin America [22, 23]. However, despite the available technology, there are still several hurdles in the way of successful food-fortification initiatives in many developing countries, including the challenge to manufacture fortified products that are within the economic reach of poor households. The role of social-marketing programs is also important; their advantages and limitations are presented as part of food-based strategies below.

Inadequate food intake is an immediate cause of malnutrition, and thus it seems logical that food and agriculture activities could also contribute to improvements in micronutrient status. The global availability of cereals has improved since the Green Revolution and is currently sufficient to meet global requirements. The rates of undernourishment, defined as inadequate caloric intake (calculated as only calories from cereals in some cases), have declined over the past 10 years. Nevertheless, more than 790 million households still do not have enough to eat [24].

The prevalence of child undernutrition, measured most commonly as the percentage of children with weight-for-age below a reference standard, has also declined somewhat over the past decade [25]. However, the persisting high rates of both undernourishment and undernutrition suggest that the distribution of food is inadequate [26, 27]. The availability of most noncereal foods, including legumes, vegetables, fruits, and animal foods, is certainly inadequate in many developing countries today [27, 28]. With urbanization, economic development, and rapidly changing dietary preferences, meeting noncereal food requirements in the future will be even more daunting [28]. Consequently, rates of micronutrient malnutrition, resulting from inadequate intake of micronutrient-rich foods, particularly animal foods, will remain high in many countries unless fortification and supplementation programs can be effectively implemented.

At the country level, food includes both domestic production and economic (food) policies to support production and import. Successful economic growth will require the development of the rural economy, which will occur through a series of changes in most countries, including diversification of agricultural production (to new products and beyond cereals) and development of the nonagricultural sector [29]. Because of the large gap between food availability, distribution, and requirements and the serious negative consequences of malnutrition, all mechanisms for increasing food availability and food quality should be promoted. For countries that are in transition from an agrarian to a more diversified rural economy, food-based strategies, such as home gardens, small-animal husbandry programs, and poultry raising, can contribute to food production and improve food availability and accessibility at the household and country level. Increased production of noncereals in the farming system should also be promoted through food policies that support crop diversification and marketing. Inclusion of poor segments of the population into these schemes is essential if the goal is poverty alleviation.

## Food-based strategies and food security

At the national, subnational, and household levels, food-based strategies should be examined in the context of food security. Traditionally, food security is categorized into three determinants: food availability, food access, and food utilization [30]. Food availability refers to agricultural production, including cash crops, livestock, and food crops. Domestic production may be enhanced by food imports. Food access refers to household purchasing power and the ability to secure foods from the market or other sources. Food utilization incorporates diverse aspects, including sufficiency of intake, food habits and preferences, intrahousehold distribution of food, food safety, and caring practices. We prefer to label food utilization as "choice," because when accessibility and availability are ensured, utilization primarily represents household and individual choices—for food, health care, and other opportunities.

Although this three-tiered classification of food security is widely accepted, the relative contribution of these three determinants of food security varies across and within country settings, in response to economic crises, civil disturbances, or natural disasters, and over time. A good understanding of the balance between availability, accessibility, and choice in a particular setting can be used to identify the most appropriate policies and programs to address food security in each situation. A comparison of several country situations will help to demonstrate the importance of this approach. Again, food security is defined as sufficient availability, access, and choice of legumes, vegetables, and fruits as well as food of animal origin.

Figure 2A represents schematically the determinants of food insecurity among poor households in a country such as Bangladesh. In rural Bangladesh, adequate food availability is still a large problem. Although Bangladesh is nearly self-sufficient in cereal production, the availability of other foods, such as dairy and other foods of animal origin, fruits, and vegetables is still well below requirements [31, 32]. In addition, more than 35% of the Bangladeshi population falls below the poverty line, and thus food accessibility is also a major constraint to achieving food security [33]. In this situation, food choice is a much less important determinant of food security. Examination of food security in Bangladesh in this manner would suggest that social-marketing or behavioral-change programs should be coupled with programs to improve food availability and access to improve food security. In fact, evidence from the Helen Keller International (HKI) home gardening and nutritional education program in Bangladesh showed that production, coupled with information on complementary feeding and opportunities for women, was associated with increased consumption and intake [34, 35].

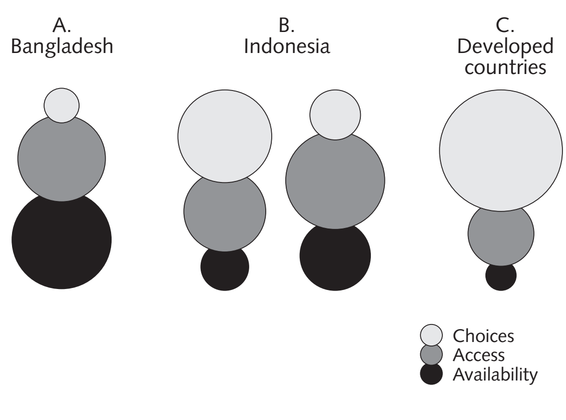


FIG. 2. Determinants of food security in (A) Bangladesh, (B) Indonesia before and after the economic crisis, and (C) developed countries

In addition to variance across countries, crises and other events can change the determinants of food security. In figure 2B we show a graphic comparison of the determinants of food security in Indonesia before and after the Asian economic crisis. Again, these figures are generalized, but they suggest that prior to the crisis, availability and access were less important determinants of food security than in Bangladesh. In this setting, choice was a more important determinant. This scenario is supported by results from a social-marketing program in Central Java that promoted increased consumption of eggs and vegetables. An evaluation of this program showed that egg consumption increased and micronutrient status improved after the campaign [36]. The economic crisis in Indonesia in mid-1997 increased prices of food and other commodities and reduced employment opportunities, thus lowering the real income and purchasing power of households. An examination of household egg consumption after the crisis revealed that weekly consumption declined [19, 37]. When prices stabilized somewhat after the crisis and household purchasing power improved again, household expenditure for animal foods increased and childhood anemia rates decreased. This scenario suggests that during this crisis period, social marketing alone would probably have been ineffective in increasing the consumption of eggs or other high-quality foods such as animal foods or fortified foods. This example in Indonesia shows how an understanding of the relative contribution of the determinants of food security can influence the type of programs that may be most effective.

Figure 2C portrays the relative determinants of food security in developed countries. In this scenario, the main determinant is choice, which involves a major role for the food industry, food packaging, and consumer food marketing that exists in many of the developed countries.

## Food-based strategies and micronutrient status

There is growing evidence that food-based strategies, including home gardening, have an impact on vitamin A deficiency and other micronutrient deficiencies. In Bangladesh, a comparison of two surveys suggested that a decline in the prevalence of night-blindness occurred among both recipients and nonrecipients of vitamin A capsules over the 15-year period. A decline in night-blindness among the group who did not receive the vitamin A capsules suggests that underlying factors, including vitamin A intake, had improved. Both of these studies showed that the current risk of night-blindness was lower among children in households with homestead gardens [38, 39]. After controlling for socioeconomic status, the prevalence of night-blindness was 3.6% among mothers in households without a garden, as compared with 3.1% among mothers in households with only a garden, 2.7% among mothers in households with only poultry, and 1.9% among women in households with both a garden and poultry ($\chi^2$ test for trend, $p < .01$). Home gardening was associated with a higher intake of vegetables and a lower risk of vitamin A deficiency among women in Central Java, Indonesia [40]. A study in Ethiopia showed that home gardening, linked with a dairy goat project, increased the intake of vitamin A–rich foods. Women and children in households who participated in home gardening had lower prevalence of night-blindnesss than the control group [41]. Also, as described above, a social-marketing campaign in Central Java led to an increase in egg and vegetable consumption and improvements in vitamin A status. These findings suggest that there is a role for food-based strategies in improving micronutrient status, particularly for vitamin A.

## Food policy and micronutrient deficiency

The links between nutrition and macro food policy and economic development have been introduced previously [42, 43]. However, although improved economic development is associated with reductions in mortality, morbidity, and malnutrition, there are limited data that allows a thorough examination of the impact of macro food policies, such as food prices, on nutritional status.

Recent analyses from the Nutrition Surveillance Project in Bangladesh showed that the decline in rice prices was strongly correlated with a decline in child nutritional status. Rice consumption did not change during this period, but the decline in rice price was associated with an increase in household expenditure on noncereal foods. The increase in expenditure on noncereal foods was also strongly correlated with the decline in child malnutrition (underweight), suggesting that an increased intake of micronutrient-rich foods contributed to this decline.

The economic crisis in Asia has provided a unique opportunity to examine nutrition and food policy. Analysis of data from Indonesia suggests that the Asian economic crisis increased the prevalence of iron and other micronutrient deficiencies and maternal wasting [19, 37]. The events of the crisis had a larger impact on household access to more expensive food items (e.g., animal foods and fortified foods), thus reducing consumption of micronutrient-rich foods. This decrease in intake of quality foods led to an increase in the prevalence of micronutrient deficiencies and ultimately to a "lost generation" and increased mortality. Since 1999, the economic situation in Indonesia has improved slightly, with an increase in the share of household food expenditure on animal foods, and the prevalence of anemia among children 12 to 23 months of age in urban poor areas in Jakarta has declined. Food policy responses to these types of crises can influence access to micronutrient-rich foods and thus can positively or negatively affect nutritional status.

## Conclusions

The broader definition of poverty and the accompanying shift in development goals makes the role of nutrition in poverty reduction and international development more evident. The links between nutrition and mortality, observed more than a century ago, are being substantiated with new research. At the same time, the source of nutrients and energy—food—is also being examined with greater intensity for the World Food Summit. Global food availability, including the availability of animal foods, and food security are major components of poverty alleviation. The role of agriculture and the importance of the development of the rural economy (despite or perhaps more importantly because of urbanization trends) make this discussion of food-based strategies in the context of food production, food security, and poverty alleviation noteworthy.

Although not within the scope of this paper, the benefits of food-based strategies towards alleviating poverty go beyond their impact on micronutrient status and maternal and child mortality. Food-based strategies can improve household income, increase women's involvement in decision-making, and enhance the skills of women and other household members, benefits that are part of the other seven International Development Goals. There is significant evidence that micronutrient malnutrition has functional consequences, such as impaired cognitive development and physical growth in children and lower work productivity [44]. Thus, prevention and control of micronutrient deficiencies also contributes to future development by improving the capabilities of the poor and enabling them to use education and technology more effectively. Finally, we cannot ignore the debate about the measurement of poverty. The inclusion of biological indicators of dietary quality may also be useful for monitoring progress towards reaching the broader goal of poverty alleviation.

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# Enhancing women's contributions to improving family food consumption and nutrition

Kathleen M. Kurz and Charlotte Johnson-Welch

## Abstract

*Despite some recent gains, the prevalence of stunting in many developing countries remains unacceptably high and warrants additional emphasis on sustainable strategies that families can use to promote better nutrition for their members. This review asks: "If women are the primary caregivers in the families, can their ability to carry out their roles be strengthened so they can improve and sustain the nutritional status of their family members?" Women play important roles in promoting and protecting the food intake and nutritional status of their family members through the food they produce and process, and the care- and health-promoting behaviors they practice. It is demonstrated that increasing their resources to carry out these roles—income, production-focused inputs, labor-saving technology, microfinance, social networks, and women's human capital—yields improvements in the nutritional situation of families, particularly children. It is recommended that experts in nutrition and other relevant fields collaborate to design multifaceted interventions focused on increasing women's resources and ability to improve nutritional benefits, thereby enhancing the sustainability of the interventions. More assessments of the process and the outcomes of such interventions need to be made rigorously.*

## Introduction

Over the last two decades, the nutrition of young children and mothers around the world has improved, thanks to applied research, policy changes, and programmatic investments [1–3]. The worldwide prevalence of underweight (low weight-for-age) in children zero to five years of age, an indicator of short-term nutritional changes, dropped from 38% in 1980 to 27% in 2000. Similarly, the rate of childhood stunting (low height-for-age), an indicator of nutritional status in the longer term, dropped from 49% in 1980 to 33% in 2000.

However, the gains have been slow in coming, and malnutrition rates still remain unacceptably high. Furthermore, improvements have been uneven between and within countries. High rates of stunting remain in Eastern Africa and South Central Asia (48% and 44%, respectively). This is of particular concern to development promoters and policy makers, because stunting captures the cumulative effect of poor nutritional status and serves as a proxy for the effects of social and economic development on children's well-being.

Although further gains can be realized from the continued promotion of existing efforts to reduce malnutrition, they may ultimately be limited unless there is additional emphasis on sustainable strategies that families can use to improve the nutritional status of their own members. One particular question is: If women are the primary caregivers in the families, can their ability to carry out their roles be strengthened so that they can improve and sustain the nutritional status of their family members?

According to UNICEF's causal framework [4], adequate nutritional status is dependent on dietary intake and health. They both are dependent on access to food, caring practices, and access to health services—the underlying factors (see right side of fig. 1). Underlying factors influencing diets are in turn dependent on resources and control over food availability and distribution within the household—one set of key basic factors influencing nutritional status.

We elaborate here a framework for conceptualizing the resources needed for good nutrition (see left side of fig. 1). The definition of resources is expanded to include those specifically linked to women's productive and care-giving roles: income and microfinance, technologies, other physical inputs, skill-building opportunities, social networks, and health and nutri-

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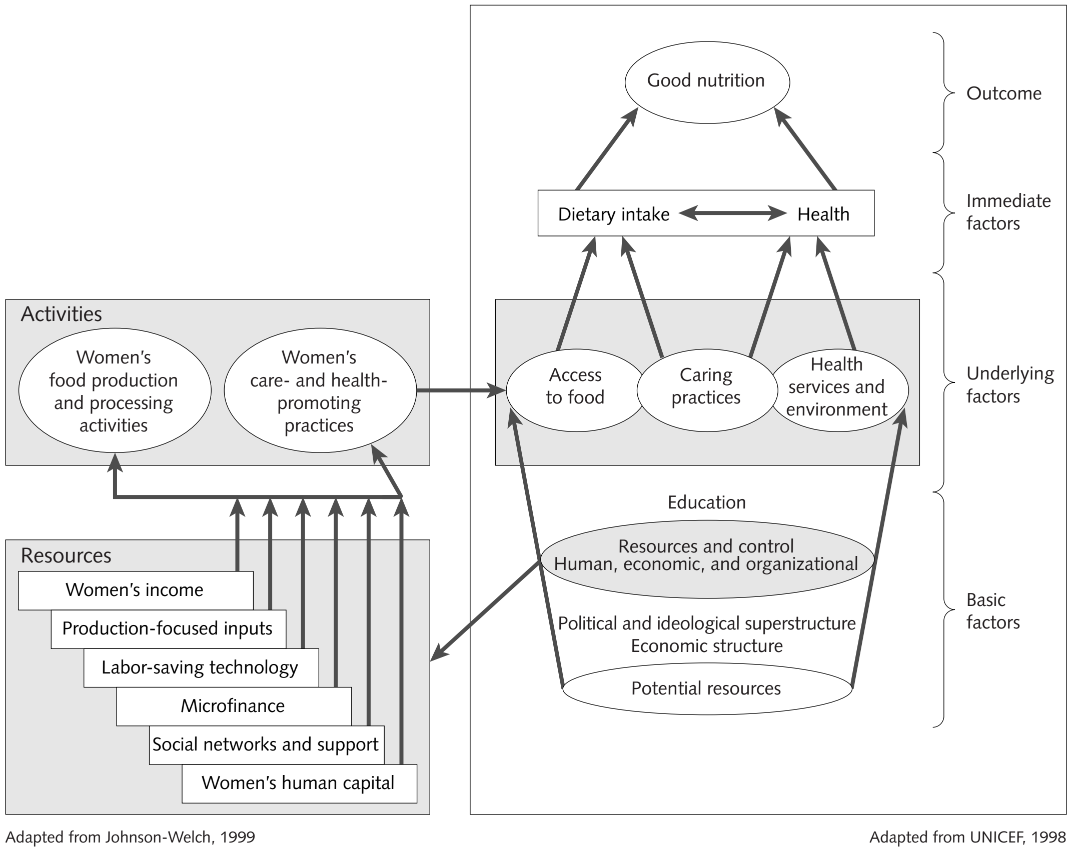


FIG. 1. Linking women's resources to good nutrition

tion information. A key assumption is that for the youngest children zero to five years old who are the most vulnerable to poor nutritional status, it is the options, resources, and behaviors of their mothers that largely determine their access to food, caring practices, and health services. Moreover, with adequate resources, women can in turn enhance agricultural production, food processing, care-giving, and health-promoting activities and benefit all family members. The achievement of these productive and care-giving activities feeds directly back into strengthening the underlying factors that determine nutritional status (right side of figure 1). This paper describes how women's activities contribute to family nutrition and provides evidence that more resources to support those activities lead to improvements in family nutrition, especially for the youngest children.

## Women's contributions to family nutrition

Women contribute directly to family nutrition and health in two main ways: through producing, processing, and selecting purchased foods, and through seeking and providing care for their family members.

### Food production and processing

Women contribute to family nutrition by bringing food into the household. They do this through agricultural work in subsistence crops and in cash crops, by gathering wild foods and producing crops such as sweet potatoes, and by activities that earn cash to buy food. Women also contribute to family nutrition by processing and selecting purchased food.

Rural women are responsible for more than 55% of the food grown worldwide and for 70% in Africa. Women also comprise 67% of the agricultural labor force in developing countries [5]. Women earn income that is used to purchase food through their work in cash-crop production as wage laborers, or help on the family's plot of cash crops. They also produce food for their families by gathering wild foods and by cultivating secondary crops with diverse nutritional benefits, including orange sweet potatoes and other vegetables, fruits, or secondary grains [6–8]. The importance of these foods is particularly great during the preharvest period of major food crops and when crops fail.

Once food is produced and enters the household, women are principally responsible for storing and processing it. Food processing can often improve the nutritional quality of foods and increase dietary diversification. Women process oilseeds, such as sunflower or sesame seeds, to produce cooking oil; transform cassava into gari, a staple food product; smoke and dry fish and meat; and process and preserve fruits and vegetables [9, 10].

### Practices to promote care and health

Another way women contribute to nutrition is by taking care of their families' health and development needs. These include use of health services for prevention, including immunizations, vitamin A and iron supplements, and growth-monitoring; treatment and remedial care; breastfeeding and other feeding practices; and engaging children in activities that stimulate their intellectual and emotional growth and development [11–14].

Ruel et al. [15] found that in Ghana good caring practices—defined in this study as appropriate child feeding and use of health services for growth-monitoring and immunizations—were strong determinants of children's height-for-age. They suggested that, even as long-term investments are being made in women's access to resources and human capital, immediate gains can be achieved by improving women's child-care practices.

In Bangladesh, children 6 to 18 months old who were growing well showed the following characteristics: they were fed at or before regular family mealtimes; they had the greatest dietary diversity of all children in the sample; they had foods prepared especially for them; and they had breastfeeding mothers with the fewest dietary restrictions [13]. Note that in this study, although income explained some of the variation in nutritional status in the entire sample, only the care variables were significant predictors of improved growth.

## Resources that support women's role in family nutrition

We have seen that women play a key role in safeguarding family nutrition. Their ability to do this well, however, is often limited by their access to resources. Key resources are income, production-focused inputs, labor-saving technology, microfinance for women, social networks and support, and women's own capacity. The literature on the impact of resources in women's control is much larger than can be reviewed in this paper, which focuses on those resources that have been evaluated for nutritional improvements or are likely to improve nutrition. Although the information in this section is divided into specific resources, the interventions featured are often designed as a package of several resources. This means any improvement in nutritional status is to be attributed to the resource package and not to any one component of it [16].

### Income

Women spend a higher proportion of the income they earn on food and other basic needs than men. Their income may be used to buy food, vitamin supplements, immunizations, or medications or to pay fees for health services.

Women are economically active in a broad range of sectors. They work in the formal, semiformal, and informal labor markets, and they earn income as wage laborers or as salaried employees in different economic sectors, including agriculture, manufacturing, retail and commerce, and services [17]. Women also earn income through their own enterprises and by selling products in markets [6,18]. Many income-earning opportunities for women put income directly within their own control and management [19]. In addition, their expenditure-replacement activities, such as hauling water, caring for basic health needs, and cleaning their homes and surrounding areas, frees up household income that might have been needed to purchase such services. This unspent income can then be used for other purposes, including buying food or health-care services.

Since women tend to spend income directly on the purchase of goods and services that promote the nutrition, health, and general well-being of their families, increasing women's income has had a greater effect on those outcomes than increasing men's income. For example, data from Brazil suggested that additional income managed by women was associated with a 3% increase in food expenditures, significantly greater than the 0.6% from income in the hands of men [20]. These results showed that women also tended to invest in foods that were associated with better health of their family members. Moreover, gender differences in food and health expenditures were reflected in children's nutritional status: child weight-for-height increased eight times faster if income was in the hands of women than in the hands of men.

The effect of women's income is also beneficial to women's own dietary intake [21]. In a study of 28,000 households in metropolitan Cebu, Philippines, women's work was significantly associated with their improved dietary intakes of energy, protein, fat, calcium, and iron, notably as a result of consuming commercially prepared foods. Furthermore, women with low incomes benefited more from this income effect than did women with higher incomes.

### Production-focused inputs

Production-focused inputs are defined here as the physical factors that improve the efficiency or productivity of an economic activity, such as improved seeds, plant varieties, and fertilizer in agricultural work. Land is also an important input, and it is expected that when women own or control land, their families' nutrition will benefit, but specific evidence of its nutritional impact was not found. In Thailand and Korea, women farmers were found to be as efficient as men after for education, age, and production-focused inputs had been controlled for [22]. Furthermore, a modeling exercise using data from Kenya projected that if women had as much access as men to resources such as land and agricultural inputs, as well as education, training, and credit, their productivity would increase 9 to 24 times [23].

In Bangladesh, women received seeds and seedlings, training in production and storage techniques, and health and nutrition information to encourage production of foods in backyard gardens for home consumption and commercial sale [24]. Household income rose by 12% through the sale of vegetables, and household expenditures fell by 10% due to their home consumption, yielding a net increase of 22% in household income. Increases in food consumption and income were associated with a larger decrease in percentage of intervention households with severely underweight children than in control households (7-point drop vs. only 3). Also, rates of night-blindness fell from 2.3% to 1.2% over two years in the intervention households. Although statistical significance was not reported, the difference in the change from before to after the intervention period for the intervention and control groups was probably sufficient to be statistically significant, given the large sample size (980 intervention households and 194 control).

In Kenya, new varieties of orange-fleshed sweet potatoes rich in β-carotene were introduced to groups of women farmers to improve crop yields and β-carotene and vitamin A intake of young children [25, 26]. Compared with the local white-fleshed sweet potato variety, which yielded 4.5 tons/hectare in Ndhiwa and Nyarongi Districts, the new varieties yielded up to 2.5 times more (7.7–11.2 tons/hectare). Food-frequency scores developed by Helen Keller International (HKI)* increased among children whose mothers participated in intervention groups that received the new planting materials and access to agricultural extension services, and the nutritional education and training in food processing and preparation, whereas they fell in the control groups that received only the new planting materials and access to agricultural extension services. In Ndhiwa and Nyarongi Districts, the intervention score increased significantly (+1.6 points) from pre- to postintervention, whereas the control group score decreased (–1.3 points), for a net increase of 2.9 points (fig. 2). This change represents a 93% increase and was highly significant ($p = .0015$). This study suggests that women's farm production offers an entry point for interventions that can improve crop yields and family's nutritional intake, and dietary intakes increased from a combination of increasing women's agricultural productivity and increasing their nutrition knowledge. Overall, increasing women's access to production-focused inputs, especially when combined with nutritional education, improves agricultural productivity, increases food available to their families, and can ultimately improve the nutritional status of family members.

* This method yields scores that reflect the number of days per week on which children under five years old were reported to have consumed animal and plant foods rich in vitamin A. According to HKI guidelines, communities with an animal source index <4 days/week or a mean weighted total food-frequency index of <6 days/week are considered at risk for vitamin A deficiency [27].

### Labor-saving technology

Another way to increase efficiency and productivity is to improve women's access to labor-saving technologies. For example, women in the Gambia were introduced to an improved manually operated ram press to extract oil from sesame seeds and compared with a control group of women who had access to motorized and physically larger presses that were, however, less reliable.* The new ram press technology enabled

* Silva-Barbeau I, Prehm MS, Samba-Ndure K, Jome K, Jawneh A, Hull SG. 1997. The direct and indirect benefits of sesame oil production on the nutritional security of women and children: the experience with woman-led monitoring of a ram press technology in The Gambia. Presented at the 16th International Congress of Nutrition, Montreal, July 27–August 1, 1997.

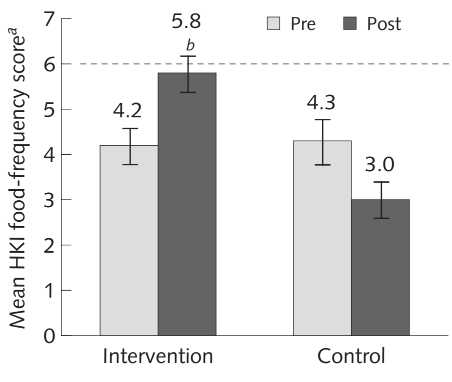


FIG. 2. Frequency of consumption of vitamin A–rich foods in Ndhiwa and Nyarongi, Kenya, $n = 154$ children zero to five years of age.

*a.* Calculated as days of consumption of animal food sources/week + [(days of consumption of plant food sources/week)/6]; values below 6 are suggestive of vitamin A deficiency.

*b.* The increase from the pre- to the postintervention period was significantly greater in the intervention group (+1.6) than the decrease in the control group (–1.3)(ANOVA, $p = .0015$)

women to produce sufficient amounts of cooking oil in less time for both home consumption and sale. Children in households with the new press had significantly larger increases in energy intakes and significantly improved nutritional status in the lean season than did children in control households, most likely due to an increased consumption of weaning foods and other table foods containing sesame seed oil.

In central Tanzania, with only one rainy season, drying vegetables is an important food-processing technique for maintaining a year-round supply of vitamin A–rich foods. In Singida District, new solar dryers were developed to save women time in comparison with traditional open-air drying and to improve β-carotene and vitamin A intake [28]. Time was saved because the dryers protected the vegetables from animals and contaminants and did not require dedicated attention by women. Nutritional education was provided at the beginning of the intervention period to promote consumption of both plant and animal sources of vitamin A. The HKI food-frequency scores for consumption of vitamin A–rich foods increased between baseline and the postintervention period 18 months later and increased significantly more in the intervention communities than in the controls ($p < .01$), mostly due to increased consumption of dried, uneviscerated sardines (fig. 3). Furthermore, although consumption of green, leafy vegetables did not increase—it was already quite high—the β-carotene content of the leaves was up to 1.6 times higher than that of leaves dried in the open air. This suggests that solar dryers can increase the β-carotene content of dried foods, and that the introduction of a technology can increase dietary intakes of vitamin A.

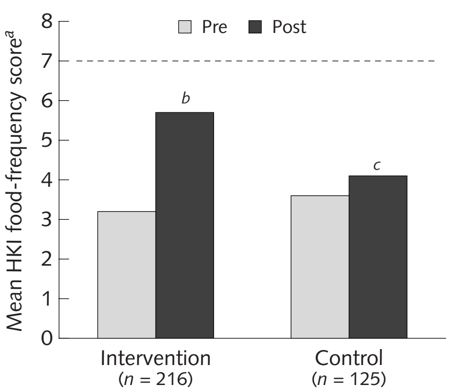


FIG. 3. Pre- and postintervention HKI food-frequency scores of children in intervention and control communities in Singida District, Tanzania, $n = 331$ children 12–71 months old.

*a.* Calculated as days on which animal food sources were consumed/week + [(days on which plant food sources were consumed/week)/6].

*b.* Significantly higher than preintervention score for intervention group ($p < .001$).

*c.* Significantly lower than postintervention score for intervention group ($p < .001$)

In Burkina Faso, a mechanical grain mill was introduced, and women took advantage of the time it saved them to prepare extra meals with different menus, thereby improving dietary intakes [10]. Similarly, an intervention study in Ghana that increased women's access to a labor-saving processing technology for production of cassava meal (gari) yielded improvements in women's and children's nutritional status [29].

### Microfinance

Women's access to microfinance services helps them meet short-term needs as well as longer-term ones through savings. Access to loans also enables women to invest in productivity-enhancing tools and equipment and other assets, such as fertilizer and improved seeds, or to purchase medicines that promote family members' health. Credit also enables women to accumulate assets, such as livestock or poultry, and these contribute to household nutrition either directly through production of milk and other food products or indirectly through income generated from market sales. Assets also provide women with an informal insurance mechanism: they can sell assets when they need cash or they can trade them to obtain other goods or services. Women typically do not obtain bank loans because they lack collateral [5]. Numerous microfinance programs have emerged to fill this gap, making small loans (about US$100) available to women without requiring physical or financial collateral.

The benefits of improving women's access to microfinance to child health and nutrition were demonstrated in Freedom from Hunger's Credit with Education Program in Ghana.* Village banking services and business training for rural women were combined with education in appropriate breastfeeding, child nutrition, treatment and prevention of diarrhea, immunization, and family-planning practices. After three years of the program, the nutritional status and health of one-year-old children of participating mothers was significantly better than that of one-year-old children of mothers either from groups in the intervention communities who did not participate or from control communities. Height-for-age Z scores improved 0.3 points among children of participating mothers, whereas they fell by 0.13 among children of mothers who did not participate and 0.11 among children of mothers from the control areas ($p = .01$).

* McNelly B. Freedom from hunger's credit with education strategy for improving nutrition security: impact evaluation results from Ghana. Presentation at the Mini-Symposium on Sustainable Nutrition Security for Sub-Saharan Women Subsistence Farmers. XXII International Conference of Agricultural Economists, August 11–14, Sacramento, Calif, USA, 1997.

Weight-for-age Z scores of children of participating mothers were also significantly higher. More participating mothers gave colostrum to their newborns rather than discarding it; more exclusively breastfed for longer; and fewer reported ever using a feeding bottle, which can be a serious source of contamination. Participants' children also had diets of higher nutritional quality that were more likely to meet energy intake requirements, and participating mothers were more likely to know how to prevent and treat diarrhea. The interest earned from loans enabled Freedom from Hunger to fund 80% of the operating costs of the program.

A study in Ethiopia found that the use of credit to enhance access to livestock yielded nutritional benefits when combined with other inputs and information. A program to provide women access to crossbred dairy goats was supplemented by agricultural inputs and health and nutrition information to improve dietary diversification [30]. Assessments were made before and after the intervention period. The results showed that young children were at lower risk of being vitamin A deficient, as assessed by dietary intake and clinical signs, if they lived in families that owned livestock and had participated in the intervention program (table 1). Access to resources enabled women to change their care and feeding practices to the benefit of children.

### Social networks and support

Another method to reduce women's time and labor demands is to share time and labor with others. This is often done through networks of friends and family, civic participation, and group membership [31]. These networks provide women direct access to labor, financial assistance, food, child care, information, and contacts or assist women in an intermediary capacity to access those resources. Moreover, women's social networks permit them to share risks, practice new behaviors, try new food crops, and supplement their labor when food shortages and other external pressures constrain their ability to meet their family's nutrition needs alone.

TABLE 1. Impact of participation in the intervention on nutritional outcomes in Ethiopia

| Outcome[a] | Greater likelihood of outcome for participants than for nonparticipants[b] |
|---|---|
| Child in the top quintile of Helen Keller International scores | 20% |
| Household had a vegetable garden | 25% |
| Child consumed milk more than 4 times a week | 22% |

*a.* Adjusted for other determinants of the outcomes.
*b.* Significantly greater likelihood, $p < .01$.

The contributions of family networks to child nutrition were shown in rural Malawi [32]. Using indices of interhousehold exchange, the results indicated that networks of family members based in urban areas or abroad contributed more to children's nutritional status (height-for-age Z scores) than did rural networks, and women's relatives had a stronger influence on children's nutritional status than did men's. Low suggests that the exchange network variables are reasonably strong proxies for access to income, particularly for women. This implies that reciprocity networks may cushion women and children from external shocks that are beyond the immediate control of an individual or household.

Men are also a source of social support for women's contributions to nutrition. Although role differentiation occurs at the household level that can limit their contributions, men play several critical roles in supporting their families' nutrition. Often they both are the gatekeepers of income and assets in the household and have strong influence over their allocation within the household. Further, men's opinions may influence women's own food consumption. In studies in Mexico and in a Thai refugee camp, women limited their food consumption during pregnancy because their husbands did not want them to gain much weight [33]. In the Thai case, nutritional education was redirected to the husbands, whose wives then gained significantly more weight each week compared with controls.

### Women's human capital

Another resource women need to improve their ability to earn income and care for their families is improvement of their own human capital by increasing their leadership capabilities, education, nutrition, and health [33–35]. Increased human capital enables women to process information better, adopt new practices and technologies, use health services, and interact effectively with health-care professionals, and their newborns are less likely to have low birth weight and more likely to be healthy [36].

#### *Leadership capabilities*

A critical element of women's human capital is their leadership capabilities. In Thailand, women were trained in problem-solving methods and community mobilization techniques and then applied these to work with their communities to identify ways of improving vitamin A, iron, and iodine status [37, 38]. The interventions included school-based distribution of iron supplements to adolescent girls; improvements in the nutritional quality of school- and home-based meals by including oil and foods rich in vitamin A and other nutrients; health and nutritional education in the schools and community; and local production of iodized salt. Baseline and postintervention data from intervention and control communities were compared, and the postintervention findings included significant improvement in vitamin A intakes among young children 2 to 5 years old, young adolescents 10 to 13 years old, and pregnant and lactating women. In addition, the vitamin A, iron, and iodine values of young adolescent girls in the intervention communities were significantly higher than those of girls in the control communities and baseline values (table 2).

Another example of how an investment in women's leadership can yield nutritional benefits is provided by a recent study in seven community kitchens (comedores) in Peru [39]. Over an 11-month period, kitchen members participated in a series of training and problem-solving workshops that aimed to strengthen their decision-making and leadership skills. They received health and nutritional information, developed and tested recipes that included locally available iron-rich foods, and learned how to adapt preparation and serving methods used at home to those more appropriate to a larger-scale production. Women also were trained as quality-assurance supervisors to ensure that the new standards and procedures were implemented in a consistent fashion. Both members and nonmembers were followed in this study. Heme iron, bioavailable iron, and vitamin C intake improved significantly among members and anemic women, though not among nonmembers and nonanemic women. The prevalence of anemia dropped significantly (from 49% to 41%, $p < .05$) in the intervention group (table 3).

### Education

The benefits of investing in girls' education to build human capital are well established. Women with some education have their first child later, make greater use of health services, and are involved in work that generates more income for themselves and their families [40]. Maternal education proved to be the most important predictor of good caring practices recently in Ghana [15]. Further, women who are educated are more likely to adopt agricultural and other technologies that increase productivity and efficiency [22]. Overall, increases in girls' education are expected to be one of the most effective ways to improve children's nutritional status [36].

### Nutrition

Improving women's general nutritional status is another investment in their human capital; it can be accomplished by decreasing their energy expenditures and increasing their nutrient intake [34, 35, 41]. Labor-

TABLE 2. Mean vitamin A, iron, and iodine values for Thai schoolgirls 10 to 13 years of age, before (1996) and after (1997) intervention

| | Intervention group | | | | Control group | | | |
|---|---|---|---|---|---|---|---|---|
| Measurement | N | 1996 | 1997 | 1996–97 change | N | 1996 | 1997 | 1996–97 change |
| Serum retinol (μg/dl) | 42 | 22.8 ± 6.9 | 33.7 ± 8.3 | +10.9[a] | 36 | 26.5 ± 6.9 | 29.8 ± 6.7 | +3.3 |
| Serum hemoglobin (g/dl) | 87 | 12.8 ± 1.5 | 13.1 ± 1.2 | +0.3 ± 1.58 | 77 | 13.4 ± 1.7 | 13.1 ± 1.4 | -0.2 ± 2.0 |
| Serum ferritin (ng/ml) | 56 | 45.6 ± 4.0 | 85.1 ± 5.1 | +39.4 ± 4.6[a] | 45 | 47.1 ± 4.0 | 54.9 ± 3.3 | 7.7 ± 2.5[b] |
| Urinary iodine (μg/dl) | 74 | 9.2 (0.0–93.3) | 12.6 (1.5–41.3) | — | 70 | 12.4 (0.0–66.1) | 12.7 (1.8–48.7) | — |

*a.* $p < .001$ (*t* test).
*b.* The pre- to postintervention change is significantly smaller in the control group than in the intervention group ($p < .001$, *t* test).

TABLE 3. Significant pre- to postintervention changes in nutrient intake among Peruvian women according to membership status in community kitchens and anemia status[a]

| Measurement | Total | Members | Nonmembers | Anemic | Nonanemic |
|---|---|---|---|---|---|
| Total iron | — | — | — | — | — |
| Heme iron | ↑ | ↑ | — | ↑ | ↑ |
| Bioavailable iron | ↑ | ↑ | ↑ | ↑ | ↑ |
| Vitamin C | — | ↑ | — | ↑ | — |
| Vitamin A | ↓ | — | — | — | — |

*a.* Dashes indicate no significant change.

saving technologies, described earlier, can help decrease energy expenditures. For instance, the cassava meal (gari) processing technology was an improvement over traditional processing methods that were more labor intensive, thereby reducing women's energy expenditure while increasing production of the food [29]. Other technologies that have this dual benefit include wells or piped water systems that are close to women's homes, and fuel-efficient stoves that reduce the need for fetching firewood [42].

Reducing micronutrient deficiencies in women is yet another investment in their human capital. Recent intervention trials found that vitamin A or β-carotene supplementation in Nepal reduced maternal mortality and severe morbidity [43, 44]. When adult women tea plantation workers received a daily iron supplement, their daily activity was 80% greater than among matched controls. Reducing iron deficiency among young children yields improvements in their cognitive development and, if projected into adulthood, these improvements can affect hourly earnings and wages [45].

#### *Health*

Improving women's health is yet another investment in women's human capital that furthers their ability to earn income and care for their families [46, 47]. Women's productivity is negatively impacted when they suffer from parasitic, skin, and infectious diseases [48]. Episodes of malaria negatively affect women and, if they occur during pregnancy, can contribute to low birthweight [49]. Women's reproductive health problems, such as reproductive tract infections, HIV/AIDS and other sexually transmitted diseases, and postabortion and obstetric complications, such as hemorrhage and obstructed labor, also impact on their ability to be economically active and provide for their families [50–53].

## Discussion and conclusions

We have shown that women play important roles in promoting and protecting the food intake and nutritional status of their family members through the food they produce and process, and the care- and health-promoting behaviors they practice. Furthermore, attention to increasing their resources for playing these roles can yield improvements in the nutrition situation of families, particularly to improve child nutritional status. These resources are income, production-focused inputs, labor-saving technology, microfinance, social networks and support, and women's human capital. In theoretical and conceptual terms, women's resources clearly contribute to family nutrition. This review has gone a step further to show in operational terms that programs can be designed and implemented to reduce women's resource constraints, which then, indeed, reduces undernutrition.

Undernutrition and micronutrient deficiencies have been stubborn problems to reduce. Making significant progress will require renewed efforts to examine how and why undernutrition is still so highly prevalent worldwide, and to reinvigorate multifaceted strategies at national and international levels. Towards this end, we suggest that one way to achieve sustained improvements is to significantly augment women's resource base.

Most of the strategies suggested here involve access to a diversity of food. Unlike the provision of supplements or the fortification of foods, food-based strategies within the household depend in large part on women and the resources they can mobilize. Women also tend to be primarily responsible for other practices that promote the care and health of family members, particularly their children.

This review cited empirical evidence from intervention studies to show that reducing women's resource constraints can improve food intake and nutritional status. It also provides numerous examples about how such interventions can be designed to accomplish the nutritional outcomes. However, further investigation is required on how best to intervene in a cost-effective manner. For example, one important question is: Should a specific nutrition component, such as a nutritional education or nutrition behavioral change promotion, be added to programs that improve women's access to resources? Some of the interventions cited above include nutritional education and others do not, yet all of them demonstrated improved nutritional outcomes. For several in particular, the study design indicated clearly that nutritional education was a crucial element of the intervention [25, 28]. Interventions improve nutritional outcomes more efficiently if a nutritional education component is included with the women's resource intervention. Overall, the impact of many more combinations of interventions needs to be investigated and disseminated under a variety of circumstances and in scaled-up settings. Although it is now clear that interventions to improve women's resources will improve family nutrition, much more analysis across programs is needed to determine how best to intervene under various circumstances, including the circumstances needed to sustain long-term effects.

It is recommended that experts involved in nutrition programs and research collaborate with experts in promotion of income, production-focused inputs, labor-saving technology, microfinance, social networks, and human capital. Through such collaboration, nutritionists could add nutrition components to these other programs and evaluate the benefits to family nutrition. Assessment should be rigorous with prospective intervention designs to determine whether benefits actually occurred during the intervention period and with appropriate comparison groups to determine whether the benefits were attributable to the intervention [54]. Furthermore, interventions should be well conceptualized to be able to deliver nutrition outcomes, and should be monitored rigorously to record how well the intervention was implemented. This is particularly important for interventions involving behavioral change, including strategies to improve access to food, promote family care and health, and gain access to the resources needed to accomplish these.

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# Nutrition communication using social-marketing techniques to combat vitamin A deficiency: Results of summative evaluation

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## Abstract

*The operational feasibility was investigated of adopting a social-marketing approach to develop a community program of nutrition communication to promote consumption of vitamin A–rich foods. Five comparable villages in a developmentally backward and drought-prone district in southern India were selected. In two experimental villages, social-marketing strategy was adopted for nutrition communication, while conventional nutritional education was implemented in two positive control villages. A large village did not receive any intervention and served as the negative control. This communication presents the results of the intervention programs carried out in the study areas over a period of one year. The results indicated that the knowledge, attitude, and practices among mothers of preschool children about vitamin A improved significantly in the experimental area after intervention. There was a fourfold increase in the intake of vitamin A–rich foods among preschool children in the experimental area, as compared with a twofold increase in the positive control. There was no change in the negative control area. There was a significant decrease in the prevalence of Bitot's spots after intervention in the experimental area (*$p < .05$*). There was no change in the other two areas. The study demonstrated the effectiveness of a social-marketing strategy for nutrition communication for the prevention and control of micronutrient deficiencies and the need for adopting innovative strategies for communicating nutrition messages.*

## Introduction

Nutrition communication aimed at changing dietary behavior to alleviate micronutrient deficiency in communities requires utilization of all components of marketing principles that contribute to the communication process. In view of the widespread prevalence of vitamin A deficiency in India and its public health significance, the National Nutrition Policy [1] set goals to eliminate blindness attributable to lack of vitamin A. Currently, the focus is on the food-based approach, as it is recognized as the most sustainable. A social-marketing approach was adopted for nutrition communication to combat vitamin A deficiency in one of the developmentally backward and drought-prone districts (Anantapur) in South India. The results of the evaluation, which was carried out after one year of intervention to assess the impact, effectiveness, and feasibility of the strategy, are presented.

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## Methods

A developmentally backward and drought-prone area in the Rayalaseema region of Andhra Pradesh in South India was chosen as the site of the study. Five comparable villages were selected. In two villages (experimental), nutritional education was carried out using the social-marketing approach. Conventional nutritional education was implemented in two positive control villages. The negative control village did not receive any intervention and was selected to study changes over time. The study was carried out in four phases: preliminary investigations, planning communication program, implementation, and summative evaluation.

### Preliminary investigations

Situation analysis was conducted using both qualitative and quantitative information to determine a reasonable and valid estimate of the prevalence of vitamin A deficiency and to assess behavioral dimensions contributing to it. Whereas quantitative studies were conducted by administering questionnaires to respondents with a set of precoded responses, the qualitative studies relied on flexible, open-ended questions to explore the beliefs, attitudes, perceptions, and culturally acceptable practices to serve as a basis for developing a nutrition communication strategy. The quantitative studies included clinical assessment of vitamin A deficiency in all the available preschool children, assessment of knowledge, attitude, and practices (KAP) among their mothers in every sixth household, dietary intake of vitamin A among the children using 24-hour recall on a subsample, food-frequency methods in every sixth household, and a market survey to assess the availability of vitamin A–rich foods in the area. Among the qualitative studies, five or six focus-group sessions [2] in each of five villages and focused ethnographic study [3] in 30 households per village were useful in designing the intervention program. The information thus collected was analyzed and utilized in the development of the communication program.

### Planning a communication program

The process for effecting a change was designed by taking into account the community's felt needs, which act as the strongest motivational force for the community to change. The major components of the process for planned change were selecting an innovation, i.e., the product (particularly with reference to motivation), establishment of communication, and identifying and utilizing the local resources necessary to bring about the change. The formative research established the community's reliance on dietary sources of vitamin A, especially from carotene-rich foods. They preferred to produce these foods in their backyards or farms to ensure a continuous supply.

The establishment of communication to enable the interchange of information between agents of change and prospective adopters, i.e., mothers of preschool children, was strengthened by identifying key members of the community and motivating them to participate actively in the communication. To create a receptive environment, the channels of communication available to the community and their choice of interpersonal communication were selected. A multimedia approach was adopted because of its advantage of parallel communication that aided in reinforcement of information communicated through one particular channel.

Certain fundamental requirements for the communication process, such as the local language for message development, interpersonal exchange, demonstration, audiovisual techniques, and the creation of a positive image, were carefully considered. The messages were developed from themes evolved from the focus-group discussions with the community members. They were pretested in order to determine whether the vocabulary, presentation format, and content were understood and acceptable, and were suitably modified to synthesize the existing community perceptions, food patterns, and beliefs, and the role of vitamin A in health. Apart from the flip chart, a logo to draw the attention of the nonliterate community was developed. It was also used on posters and displayed at strategic places in the experimental villages. Active members from the community were chosen as "Agents of Change." Finally, the implementation of the intervention and adoption of behavior change were based on collaborative efforts of the agents of change, the target community, and allied agencies in the field of development. The local health functionaries from the State Government and Social Forestry Department (to supply seedlings of carotene-rich foods) were approached for the future sustainability of the intervention program.

### Implementation of the communication program

The implementation of the overall communication strategy, i.e., dissemination of messages, educational materials, and face-to-face educational activities, was carefully supervised so that the communication channels and resources would be utilized to the maximum. In the experimental village, community participation was ensured at all stages of the development of intervention program and implementation. Leaders of a women's group known as DWCRA (Development of Women and Child in Rural Areas) volunteered to encourage their fellow members to participate in the program and to provide facilities and support for organizing group discussions, cooking demonstrations, and distribution of horticultural inputs. The schoolchildren (fourth and fifth graders) along with Anganwadi Workers, who were village-level honorary female workers of the government-operated Integrated Child Development Services (ICDS) program, undertook educational activity using the visual aids. The logo appeared on posters and badges, was used by Anganwadi Workers when initiating a group discussion, and was worn by schoolchildren to identify themselves as part of the program. A street play was developed incorporating the objectives of the study and was presented in different places in each village to cover the entire village population. The activities of the project were dovetailed into the ICDS program so that the joint efforts would be more beneficial. A well-baby show, annually organized by the ICDS, was used as a venue to incorporate the project messages during the group meetings with the mothers. As a part of the show, a rally was also organized by the schoolchildren.

Although the program was carefully designed to mobilize the community and make it a social campaign in experimental villages, a conventional top-down educational approach was allowed in the positive control villages, without the involvement of the community in the development of the intervention program. A flip chart that provided scientific facts about the consequences and prevention of vitamin A deficiency and technical guidance to raise the home garden was distributed to the Anganwadi Workers during their regular group discussions with the community members. Although the inputs to organize slide shows, group discussions, and cooking demonstrations, including horticultural inputs, were similar in both the experimental and the positive control areas, the communication process was conventional in terms of little or no input from the community.

In the negative control village, the communication remained status quo, to estimate the natural changes that might occur over time, whereas in the positive control villages, the Anganwadi Workers were motivated to provide nutritional education during the intervention period.

#### Monitoring

Regular monitoring, using a triple-A approach of assessment, analysis, and action, was undertaken for the overall appraisal of the program in terms of its intended objectives and operation or any modifications necessary to improve it further.

Initially, seeds of spinach and amaranth were distributed in accordance with the community's preference. However, an evaluation during the first quarter of the intervention period revealed that the community felt a need for a continuous supply of carotene-rich foods. Therefore, seedlings of drumstick (*Moringa oleifera*), gogu (*Hibiscus cannabinus*), and papaya were made available in both the experimental and the positive control areas with support from the Social Forestry department. The schoolchildren in the experimental villages played an active role in the education campaign. They encouraged their own families, and to some extent, their neighbors to take up home-gardening and to recruit women for group meetings or cooking demonstrations. The mothers of some of these children acted as role models for other women in the locality.

Some volunteers of the DWCRA in the experimental villages were trained in organizing cooking demonstrations that were held late in the evening to allow women's participation. The demonstrations were supplemented with information about cooking procedures to minimize nutrient losses and ways of incorporating the carotene-rich foods in the diets of young infants, preschoolers, and older children. Care was taken to cover different social groups in the whole village. Cooking demonstrations were held twice a week to generate interaction between those who were exposed and those not exposed to the cooking demonstration.

In accordance with the theoretical framework of "diffusion of innovations," these demonstrations were held in the household of an opinion leader or traditional birth attendant, who could influence others to follow the right procedure, or a household with a well-grown home garden to serve as a model to motivate others. Continuous monitoring helped to build up close rapport, and thus the confidence of the community in the project aims and objectives gradually increased.

#### Evaluation summary

The intervention program was implemented for a period of one year (1997–1998), after which a summative evaluation was undertaken. Both the process and the impact variables were included in the evaluation to assess the impact, effectiveness, and feasibility of the intervention. The process variables included outreach of messages, the community's perception and choice about agents of change, preferred communication methods, and exposure to educational aids. The impact indicators included the prevalence of Bitot's spots, vitamin A intake, and change in knowledge, attitude, and practices of the community.

- » Study villages were enumerated to collect demographic profiles and identify households with preschool children.
- » Clinical examination of all available preschool children was done by making house visits for the assessment of prevalence of vitamin A deficiency.
- » A pretested and precoded KAP questionnaire was administered in every third household on mothers with preschool children using systematic random sampling.
- » The presence of various carotene-rich foods and plants in the households or gardens after intervention was assessed and compared with preintervention to determine the effectiveness of the social-marketing strategy.
- » Evaluation of the carotene and vitamin A intake applied the modified International Vitamin A Consultative Group (IVACG) semiquantitative diet survey on a subsample of preschool children. The traditional 24-hour recall diet survey method was modified by incorporating the IVACG guidelines to estimate the intake of carotene-rich foods during the previous 24 hours by using standard cups and spoons [4]. The IVACG guidelines suggest scoring each food preparation based on its vitamin A activity (μg RE/100 g) and ranking them into low-, moderate-, or high–vitamin A foods, while assessing the adequacy of the intake of vitamin A. A pilot study did not show a good correlation between the risk category the child was assigned and the actual intake. The main reasons were that the recipes in the rural areas were not standard and uniform, and the range of 50 to 250 μg suggested for ranking the food into moderate groups was found to be too wide. This led to problems while assessing the risk category of the child.

Therefore, a modified traditional dietary assessment was employed with main emphasis on vitamin A– or carotene-containing foods, and the actual intake of carotene in terms of vitamin A was estimated and compared with the preintervention intake.

» To complement the 24-hour recall information, the frequency (daily, weekly, and monthly) of consumption of vitamin A–rich foods was collected in every third household using systematic random sampling.
» Assessment of process variables was conducted in every third household. These indicators were assessed using pretested and precoded questionnaires in every third household.

### Statistical analysis

The statistical analysis was performed with SPSS 7.5 version for Windows. The change (cross-sectional) in the outcome variable (prevalence of vitamin A deficiency, KAP, frequency of intake of carotene-rich foods, presence of plants rich in carotene) within each study area and among the three areas was compared to their preintervention using Z scores to assess the significance of differences ($p < .05$ level). The mean intakes of vitamin A in different areas were compared by Student's *t* test after log transformation of the data.

KAP variables that were important in the context of the objectives of the study were identified and given scores on a five-point scale in which the most positive response received maximum score.

## Results

### Demographic and socioeconomic status

No significant changes between pre- and postintervention phases were observed in the demographic and socioeconomic status of the community. Nearly 80% of the population belonged to the socially backward scheduled caste or backward caste and scheduled tribe. The proportion of the scheduled tribe and backward caste population was higher in the experimental villages than in the control villages. More than 60% of the heads of households were illiterate, and 42.4% had no land. Agricultural work, either as laborers or landowners, was the main occupation of nearly 70% of the households. Most of those with landholdings of 2.5 acres or more cultivated their lands for subsistence. About 75% of the families lived in pucca houses (having brick and cement walls with a reinforced concrete cement roof) (table 1). Sixty-eight percent were nuclear families, and the average family size was 4.85 members. About two-thirds of the households had a monthly family income of less than Rs.2, 000/- (US$1 = Rs. 46).

### Outcome variables

#### *Bitot's spots*

There was a significant decline ($p < .05$) in the prevalence of Bitot's spots in the experimental area after one year of intervention to 3.3% from about 7.4% (fig. 1). There were no significant changes in the prevalence of Bitot's spots from the baseline in the other areas.

#### *Dietary intake of vitamin A–rich foods*

In the experimental area, there was an increased intake of carotene-containing foods, reflecting the efficacy of the intervention.

*Carotene-containing foods.* The mean preintervention total intake of carotene foods (papaya, mango, and green leafy vegetables) among preschool children was 42 g in the three areas. This amount would meet three-quarters of their RDA. After the intervention, the mean intake was 101 g in the experimental area, 67 g in the positive control area ($p$ =.104), and 48 g in the negative control area. The latter was significantly lower than the experimental area ($p$ = .01)(table 2). Both the pre- and postintervention surveys were conducted during the summer, and the postintervention intake was more than twice the preintervention intake in the experimental area. In the negative control area, no change was observed in the intake between baseline and postintervention.

*Retinol intake.* The mean intake of retinol in the experimental area during postintervention was 631 μg, which was higher than the intake in the positive control area (399 μg) and the negative control area (213 μg) ($p$ = .024). However, the mean intakes in the experimental and positive control groups were not significantly different ($p$ = .105). In the experimental area, nearly half of the preschool children met their daily requirements of retinol, whereas in the positive and negative control areas, only 38% and 17.2%,

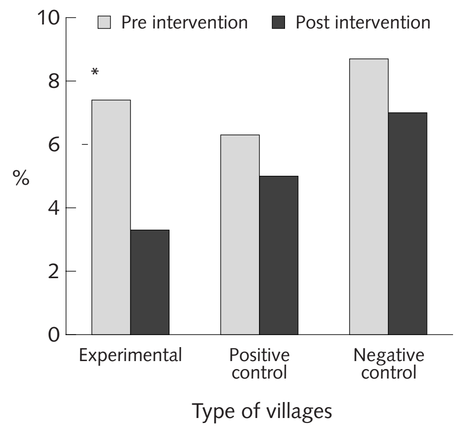


FIG. 1. Prevalence of Bitot's spots. * $p < .05$

respectively, met their requirements. The proportion of preschool children with retinol intake less than 50% of the RDA was about 60% in the positive control area and 70% in the negative control area.

*Frequency of intake of carotene-rich foods.* In the experimental area, there was a significant fourfold rise from baseline to postintervention in the proportion of mothers feeding green leafy vegetables to their preschool children three or more times per week. In the positive control area, there was a twofold increase, whereas the proportion remained the same in the negative control area (table 3).

The proportion of preschool children consuming green leafy vegetables less than three times per week was 58% in the experimental group, as compared with 66% in the positive control area and 85% in the

TABLE 1. Socioeconomic profile of the head of the household at postintervention

| Characteristic | Experimental (*N* = 567) | Positive control (*N* = 707) | Negative control (*N* = 423) | Pooled (*N* = 1,697) |
|---|---|---|---|---|
| | % of households | | | |
| Caste | | | | |
| Scheduled caste | 22.8 | 42.1 | 33.8 | 33.6 |
| Scheduled tribe | 13.9 | 4.1 | — | 6.4 |
| Backward caste | 554.0 | 36.5 | 48.0 | 45.6 |
| Other caste | 79.0 | 17.3 | 18.2 | 14.4 |
| Occupation | | | | |
| Agricultural labor | 372.0 | 44.3 | 45.6 | 42.2 |
| Tenant cultivation | 3.2 | 2.0 | 5.9 | 3.3 |
| Landowner | 26.3 | 32.5 | 23.4 | 28.2 |
| Artisan | 11.3 | 7.1 | 13.0 | 10.0 |
| Other | 22.0 | 14.1 | 12.1 | 16.3 |
| Literacy | | | | |
| Illiterate | 58.7 | 61.6 | 65.5 | 61.6 |
| Just literate | 10.9 | 7.6 | 10.4 | 9.4 |
| Primary school | 12.0 | 16.1 | 13.7 | 14.1 |
| Secondary school | 12.2 | 9.6 | 8.7 | 10.3 |
| High school and above | 6.2 | 5.1 | 1.7 | 4.6 |
| Landholdings | | | | |
| None | 50.9 | 37.2 | 39.5 | 42.4 |
| Marginal | 24.6 | 30.7 | 39.2 | 30.8 |
| Small | 14.8 | 19.5 | 13.5 | 16.4 |
| Big | 9.7 | 12.6 | 7.8 | 10.4 |
| House | | | | |
| Mud-thatched | 15.5 | 26.3 | 36.2 | 25.2 |
| Pucca[a] | 84.5 | 73.7 | 63.8 | 74.8 |
| Type of family | | | | |
| Joint | 18.3 | 22.2 | 16.1 | 19.4 |
| Extended | 12.4 | 11.7 | 16.1 | 13.0 |
| Nuclear | 69.3 | 66.1 | 67.8 | 67.6 |
| No. of family members (average 4.85) | | | | |
| 0–2 | 13.6 | 10.9 | 10.9 | 11.8 |
| 3–5 | 59.3 | 57.4 | 56.5 | 57.8 |
| 6–10 | 24.9 | 29.6 | 29.6 | 28.0 |
| 11–15 | 1.8 | 1.8 | 2.8 | 2.1 |
| 16–20 | 0.4 | 0.3 | 0.2 | 0.3 |
| Income (Rs./month) | | | | |
| <1000 | 24.0 | 19.9 | 42.8 | 27.0 |
| 1001–2000 | 40.1 | 39.8 | 37.6 | 39.4 |
| 2001–4000 | 31.8 | 34.2 | 18.2 | 29.4 |
| >4000 | 4.1 | 6.1 | 1.4 | 4.2 |

*a.* Houses with brick and cement walls and reinforced cement concrete roofs.

negative control area postintervention. The negative control area was at a higher risk than the positive control area, and the experimental area was at least risk according to the World Health Organization (WHO) risk criteria [5].

There was also significant improvement in the proportion of preschool children consuming other carotene foods, such as papaya, at least three times per week (baseline 3.2% vs. final 25.7%, $p < .05$) in the experimental area compared with the two control areas.

*Consumption of preformed vitamin A.* The proportion of children consuming milk at least three times per week showed a marginal increase over the preintervention value in all three areas. There was no significant increase in the intake of eggs in either the negative or positive control areas, and the increase in the experimental area was not significant.

*Food intake during pregnancy and lactation.* A total of 108 pregnant and 31 lactating women were studied in the three areas during postintervention. At the end of the study, in the experimental area 45.3% were consuming green leafy vegetables three or more times per week, as compared with 31.7% in the positive control and 16.9% in the negative control areas.

TABLE 2. Intake of carotene-rich foods by preschool children during postintervention

| Area | $N$ | Carotene foods (g) Mean | Carotene foods (g) SD | RE (μg) Mean | RE (μg) SD |
|---|---|---|---|---|---|
| Study | 54 | 101.3[a] | 103.1 | 630.8[a] | 710.2 |
| Positive control | 71 | 67.4[abc] | 70.8 | 398.4[abc] | 467.3 |
| Negative control | 29 | 48.1[bc] | 55.8 | 212.9[bc] | 251.7 |
| $p$ values between areas (values with same superscript are not significantly different) | | 0.01 | | 0.024 | |

*Foods restricted during pregnancy.* In the experimental area, a higher percentage of the target groups (28.8%) ($p < .01$) consumed all types of foods without restriction. as compared with 16.3% and 14.3% in the positive and negative control areas, respectively. The percentage of women avoiding papaya during pregnancy was significantly lower (67.0%, $p < .01$) in the experimental area during postintervention than in the control areas. The proportion of respondents citing fear of abortion as the main reason for avoiding papaya was also significantly ($p < .001$) less in the experimental area (63%) than in the positive control area (73.3%). The most frequently cited reason for avoiding papaya, apart from fear of abortion, was "elders' advice" in all three areas.

### Knowledge, attitudes, and practices

A majority of the 560 mothers of preschool children interviewed for KAP were illiterate and under 35 years of age. Of these, 83% had been exposed to the innovative nutritional education. The results of this exposure indicated the following.

#### *Awareness of vitamin deficiency*

During postintervention, there was a considerable improvement in the community's awareness regarding the role of diet in general health and about vitamin A–rich foods and eye diseases. At baseline, less than 30% of respondents in all three areas knew that dietary deficiency was a cause of eye disease. However, after the intervention, 63.4% in the experimental area stated that inadequate diet leads to eye disease, as compared with 46.0% in the positive and 19.5% in the negative control areas ($p < .001$ (table 4). Of these, 66% in the experimental area could describe the common manifestations of xerophthalmia, including night-blindness and Bitot's spots, as compared with 36.7% in the negative control area. The difference between the values in the experimental area and the positive control area (61.7%) was not significant.

TABLE 3. Frequency of consumption of green leafy vegetables by preschool children

| Frequency | Preintervention: Experimental ($N = 63$) | Preintervention: Positive control ($N = 87$) | Preintervention: Negative control ($N = 53$) | Postintervention: Experimental ($N = 191$) | Postintervention: Positive control ($N = 215$) | Postintervention: Negative control ($N = 154$) |
|---|---|---|---|---|---|---|
| | % of children | | | | | |
| ≥ 3/wk | 9.8 | 15.9 | 14.3 | 41.8 | 34.5 | 15.1 |
| 2/wk | 22.0 | 22.3 | 22.9 | 43.8 | 29.0 | 32.4 |
| 1/wk | 47.2 | 41.2 | 33.6 | 12.4 | 30.6 | 29.4 |
| Fortnightly | 9.3 | 11.5 | 12.6 | — | 1.2 | 9.0 |
| Occasionally | 4.7 | 3.4 | 8.6 | — | 2.1 | 5.3 |
| Never | 7.0 | 5.7 | 8.0 | 2.0 | 2.6 | 8.8 |

TABLE 4. Knowledge of features of vitamin A deficiency

| Feature | Preintervention | | | Postintervention | | |
|---|---|---|---|---|---|---|
| | Experimental (*N* = 63) | Positive control (*N* = 87) | Negative control (*N* = 53) | Experimental (*N* = 191) | Positive control (*N* = 215) | Negative control (*N* = 154) |
| | % of respondents | | | | | |
| Inadequate diet causes eye disease | $28.6^{d}$ | $21.8^{e}$ | 17.0 | $63.4^{a}$ | $46.0^{b}$ | $19.5^{c}$ |
| Awareness | | | | | | |
| Night-blindness | $41.3^{d}$ | 37.9 | $32.1^{c}$ | $68.6^{a}$ | $55.8^{b}$ | $26.6^{c}$ |
| Bitot's spots | $27.0^{d}$ | 50.6 | $64.2^{f}$ | $50.3^{a}$ | $30.2^{b}$ | $8.4^{c}$ |
| What causes night-blindness and Bitot's spots? | | | | | | |
| Vitamin A deficiency | — | 1.4 | — | 2.0 | 3.0 | 2.3 |
| Lack of carotene-rich foods | 11.8 | 2.8 | 2.3 | $59.9^{a}$ | $30.3^{b}$ | $13.6^{c}$ |
| Poor diet | 7.8 | 12.5 | 22.7 | 10.9 | 21.2 | 20.5 |
| Don't know | 80.4 | 83.3 | 75.0 | 27.2 | 45.5 | 63.6 |

Values with different superscripts are significantly different at either $p < .01$ or $p < .001$. Significant differences between preintervention and final postintervention values in experimental area ($^{d}$), positive control ($^{e}$), and negative control ($^{f}$).

During postintervention, 68.6% of respondents in the experimental area identified night-blindness correctly, as compared with 55.8% in the positive control area ($p < .01$) and 20.6% in the negative control area ($p < .001$). Similar results were noted with regard to Bitot's spots.

Comparison of data at pre- and postintervention within each area revealed that a significantly higher proportion of women in the experimental area identified both night-blindness and Bitot's spots correctly. Interestingly, in the positive and negative control areas, there was a significant reduction in the proportion of women who identified the vitamin A deficiency signs correctly during postintervention ($p < .001$). The preintervention awareness of night-blindness and Bitot's spots in these areas was due to an earlier intensive horticultural intervention.

The proportion of respondents who stated that night-blindness was caused by lack of vitamin A–rich foods increased significantly ($p < .001$) from 11.8% at baseline to 59.9% in the experimental area after intervention. In the positive and negative control areas, the percentage of respondents reporting the same was significantly lower ($p < .001$).

### Importance of green leafy vegetables

During the postintervention, 43% of the experimental group indicated that green leafy vegetables should be eaten for good eyesight, as compared with only 27.9% and 17.2% in the positive and negative control groups, respectively. The percentage of respondents stating that green leafy vegetables should be fed to preschool children for good vision was significantly higher during the postintervention (63.6%) in the experimental area than in the positive (32.1%) and negative (13.3%)control areas ($p < .001$)(table 5).

### Cooking practices

Observations of the community before intervention indicated improper cooking practices that could affect vitamin A retention from the vegetables. Therefore, during intervention, good cooking practices were demonstrated. Postintervention results indicated that a higher number of respondents in the experimental areas adopted proper cooking methods, such as sautéing green leafy vegetables in oil or closing the lid while cooking, compared to positive control villages.

### Horticultural activities

In order to increase the availability of carotene-rich foods at the household level, seeds and seedlings of some seasonal and perennial green leafy vegetables were supplied in the experimental and the positive control areas. After a year of intervention, 67% in the experimental area were growing carotene-rich foods in their backyards, as compared with 35% in the positive and 14% in the negative control areas (fig. 2). Both pre- and post-surveys were conducted during the peak summer months. The results indicated that 128 households in the experimental area had home gardens. Of these, about 80% to 90% grew seasonal plants, such as amaranth, spinach, or gogu (*Hibiscus cannabinus*) during the rainy and winter seasons (table 6). About 10% to 15% continued to grow them even during peak summer (postintervention). In the positive control area, although about 70% or more households with home gardens grew these green leafy

TABLE 5. Knowledge of advantages of feeding green leafy vegetables to preschool children

| | Preintervention | | | Postintervention | | |
|---|---|---|---|---|---|---|
| | Experimental (*N* = 62) | Positive control (*N* = 87) | Negative control (*N* = 48) | Experimental (*N* = 187) | Positive control (*N* = 209) | Negative control (*N* = 143) |
| Advantage | % of respondents | | | | | |
| Good for health | 45.2 | 56.5 | 68.8 | 34.2 | 62.5 | 55.2 |
| Rich in vitamin A | 17.6 | 9.2 | 6.3 | 0.5 | 1.0 | 4.2 |
| Good for vision | 21.0 | 17.2 | 20.7 | 63.2 | 32.1 | 13.3 |
| Aids blood production | — | 3.4 | — | — | — | — |
| Generally eaten | 8.1 | 2.2 | — | — | 1.5 | 22.4 |
| Don't know | 8.1 | 11.5 | 4.2 | 2.1 | 2.9 | 4.9 |

vegetables, less than 10% had either amaranth or spinach during the postintervention survey.

The presence of perennial carotene-rich plants such as drumstick (*Moringa oleifera*) and papaya is of significance for providing a source of dietary carotene throughout the year. In the experimental area, about 70% of the households with home gardens grew these plants, and more than half of them were able to maintain them even in summer. In the positive control area, on the other hand, only about 40% of households grew these plants, although the saplings were distributed free of cost in these villages, and only 17% and 24% had drumstick and papaya, respectively, in their backyards at the time of evaluation. In the negative control area, about 14% of the households surveyed had home gardens. A higher proportion of households belonging to the scheduled and backward castes had home gardens in the experimental area than in the positive control areas (70.3% and 15.4%, respectively).

The KAP scores were significantly higher in the experimental group than in the control groups after the intervention (table 7). The mean KAP scores at preintervention did not differ between the areas.

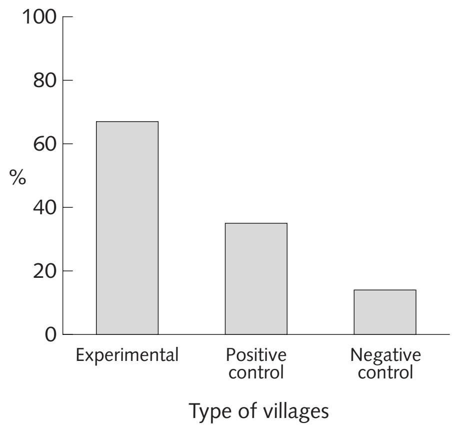


FIG. 2. Adoption of home gardening at postintervention

## Process variables

Process variables were assessed to obtain feedback on the process of implementation, as well as to explain why a particular program is effective. After the intervention, 180 respondents in the experimental area and 241 in the positive control area, mostly women, were interviewed regarding their perception of process variables, such as outreach and coverage, preference for agent communicator, and educational aids.

### Outreach of the messages

In the experimental area, 83.3% of households reported they had been been exposed to nutrition communication. This indicated better coverage than in the positive control area (47.3%)(fig. 3). In both the

TABLE 6. Households adopting home gardening of green leafy vegetables at postintervention

| | Experimental (*N* = 128) | | Positive control (*N* = 76) | | Negative control (N = 22) | |
|---|---|---|---|---|---|---|
| Crop | Grown during rainy/winter season | Present at time of interview | Grown during rainy/winter season | Present at time of interview | Grown during rainy/winter season | Present at time of interview |
| Amaranth | 82.8 | 11.7 | 67.1 | 6.6 | 45.5 | — |
| Spinach | 90.6 | 10.2 | 72.4 | 9.2 | 27.3 | 4.5 |
| Gogu | 89.8 | 14.8 | 76.3 | 18.4 | 68.2 | 9.1 |
| Drumstick | 70.3 | 41.4 | 39.5 | 17.1 | 13.6 | 9.1 |
| Papaya | 68.8 | 41.4 | 38.2 | 38.2 | 36.4 | 27.3 |

TABLE 7. Knowledge, attitude, and practice (KAP) scores (mean ± SD) at postintervention[a]

| Variable | Experimental (*N* = 191) | Positive control (*N* = 215) | Negative control (*N* = 154) |
|---|---|---|---|
| Knowledge | 51.68 ± 13.16 | 42.62 ± 2.92 | 33.48 ± 8.57 |
| Attitude | 37.84 ± 6.30 | 32.31 ± 5.67 | 29.25 ± 4.63 |
| Practice | 115.21 ± 35.55 | 90.67 ± 25.38 | 72.92 ± 5.74 |
| Total KAP | 204.73 ± 46.11 | 165.59 ± 34.83 | 135.65 ± 22.89 |

*a.* All values are significantly different between groups.

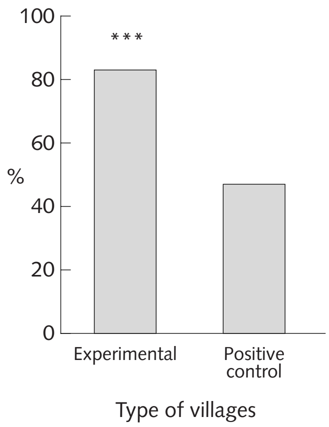


FIG. 3. Coverage for nutrition communication. *** $p < .001$

areas, the respondents stated that the importance of carotene foods, sequelae of vitamin A deficiency, and its prevention were discussed during these sessions. About 90% of the respondents reportedly understood the messages.

Nonavailability of the green leafy vegetables at the household level was one of the main reasons for poor intake. Hence, a message emphasizing "increased production and consumption of green leafy vegetables, at least on alternate days, to improve health and protect the eyesight" was communicated during the intervention. More than 80% of the respondents in both experimental and positive control areas recalled this message. Although the community had no difficulty in recalling the signs of vitamin A deficiency and its prevention, only 11% in the experimental area were able to recall the actual message about vitamin A deficiency. A study using social marketing in Bangladesh also found that respondents could recall a message that conveyed the benefits of consuming green leafy vegetables, rather than the message on night-blindness per se [6]. Thus, it appeared that backward rural communities could retain messages that increase their awareness about benefits of good nutrition for general health better than scientific information about a disease per se (vitamin A deficiency) with which they might not be able to identify.

Sixty percent of the households in the experimental area felt that the content of the messages on increasing the availability and consumption of green leafy vegetables could easily be understood and adopted, versus 47.6% in the positive control area.

Questions on the prevention of night-blindness, the importance of colostrum, and green leafy vegetables were asked to evaluate the changes in the perceptions of the respondents as a result of the intervention. It is possible that changes in awareness and practice could be achieved even in those members of the community who are not directly exposed to the intervention. Therefore, attempts were made to interview as many respondents as possible on several questions related to different aspects covered during the nutrition communication. The results indicated that 63.3% of respondents from the experimental area could state that regular consumption of carotene foods would prevent night-blindness, versus 24.5% in the positive control area (table 8).

The use of prevalent beliefs about foods as building blocks for adding newer concepts led to more favorable attitudes in the community regarding the messages. For instance, the community's perception that ragi (millet, *Eleusine coracana*) and green leafy vegetables were both "cooling" and therefore good for the body was reinforced by a message that encouraged the regular addition of these foods to the diets of young children. In the experimental area, 46% of households believed that the combination of ragi with green leafy vegetables helped to keep the body cool (healthy), in addition to protecting the eyesight in children, as compared with 21% in the positive control area.

### Preference for agents of change

Almost all of the respondents in both areas recognized the research team as important providers of information. However, regarding choice of agents from the village level, 28.7% preferred schoolchildren and 18.0% preferred Anganwadi Workers as agent communicators ($p < .05$). A majority (70%) of schoolchildren selected as agent communicators were 10 to 11 years old (4th and 5th grade), who could easily understand and deliver simple messages on vitamin A deficiency to the women in their neighborhoods.

### Exposure to educational aids

About 70% of households in the experimental area were exposed to and could recall three or more edu-

TABLE 8. Responses of women on aspects concerning vitamin A deficiency and colostrum

| Response | Experimental ($N = 180$) | Positive control ($N = 241$) |
|---|---|---|
| Prevention of night-blindness | | |
| Regular consumption of carotene-rich foods | 63.3 | 24.5*** |
| Consumption of vitamin A from vegetable and animal sources | 5.0 | 2.9 |
| Medical treatment | 1.1 | 1.2 |
| Don't know | 30.6 | 71.4 |
| Give colostrum to newborn | | |
| Yes | 47.8 | 45.2 |
| No | 37.8 | 48.1 |
| Don't know | 14.4 | 6.7 |
| If yes to preceding question, what are the advantages? ($N = 86$ experimental, 109 positive controls) | | |
| Keeps the baby healthy | 48.8 | 31.2 |
| Follow elders/traditional birth attendant instructions | 17.4 | 34.8 |
| Advised by doctor or investigator | 20.9 | 6.4 |
| To satisfy hunger of the body | 1.2 | 19.3 |
| Don't know | 11.7 | 8.3 |

*** $p < .001$

cational aids (logo, flip charts, slide shows, cooking demonstration, video/television). In the positive control area, nutrition communication was not satisfactory in terms of either number or type of educational aids. Only about 49% remembered seeing any aid, and 33% recalled only one educational aid.

Compared with two-thirds of the women in the experimental area, only 8% in the positive control area reported that an agent communicator made three or more visits, indicating better implementation of the communication program in experimental area.

### Logo

The logo served not only as an educational aid, but also as a tool to constantly remind the community about the significance of carotene-rich foods. About 60% believed that the carotene-rich foods displayed below a pair of eyes in the logo represented the foods that should be eaten for the health of the eyes. Twenty-three percent stated that the foods shown in the picture prevented night-blindness and Bitot's spots, whereas about 16% were unable to explain them. Because the majority of the rural community is illiterate, pictorial educational aids are useful to convey the message.

### Preferences regarding channel of communication

Focus-group discussions revealed that the community preferred an interpersonal channel of education, because they felt that it allowed direct interaction between the provider and the receiver during preintervention. Since several aids and channels were used, the community's order of preferences and reasons for the same were ascertained at the end of the intervention. Cooking demonstrations on different methods of preparing green leafy vegetables were the most popular and preferred educational channel in the experimental (55%) and positive control areas (73.7%). Of these, about 73.4% in the experimental area and 67% in the positive control areas had tried out the simple recipes in their homes, incorporating spinach, drumstick leaves, and *Basella alba*. The community reported that the demonstrations provided them the opportunity to learn to cook green leafy vegetables in different ways.

The order of preference of other channels in the experimental area was person-to-person communication, slide shows, and street plays, whereas in the positive control areas, the order was person-to-person communication, television, radio, and slide shows.

### Street plays

Street plays were evaluated on the basis of their effectiveness in educating the community regarding the objectives of the program. Although more than one street play was organized in each of the experimental villages in an effort to cover the entire population, and particularly women, only 41% of the respondents had seen the street play. Of these, more than 90% understood the main theme of the play and were able to recall specific instances from the play, even after three months. About 56% of the respondents appreciated the concept of the story, because the local dialect and situations were depicted realistically and the community could identify with the characters.

## Discussion

The study attempted to assess the feasibility and impact of innovative methods of nutrition communication using social marketing. The innovative approaches were involvement of the community to decide themes for communication, utilizing local women and schoolchildren as agent communicators, developing a logo to give identity to the program apart from being an educational aid, staging street plays with the help of a local organization, and involving the departments to provide support. After one year of implementation, there was a significant improvement in the behavior of the community in terms of both production and consumption of vitamin A–rich foods in the area where the social-marketing approach was adopted. The study demonstrated that a systematic adoption of commercial marketing techniques would considerably enhance the success of programs aimed at improving the nutritional status of the community.

In the experimental area, the innovative social-marketing approach employed for communication resulted in a significant decrease in the prevalence of vitamin A deficiency. The extent of decrease in the positive control areas was not significant, suggesting that conventional nutritional education, wherein the community plays a passive role, was not very effective. The prevalence of vitamin A deficiency, however, in all the areas continued to be well above the WHO criterion as well as the national average of 0.7% [7, 8]. In an earlier community-based study, after three years of participation in a horticultural intervention program, the prevalence of Bitot's spots in preschool children decreased by more than half as compared with those who had participated for only one year [9]. In the present study, on the other hand, even the short duration of one year of innovative social marketing could effect as much decline in the prevalence of vitamin A deficiency.

The changes in dietary intakes were found to be in line with those of the Thailand study [10] indicating improvement in vitamin A intake in the target population. In a similar study in Bangladesh, there was a twofold increase in green leafy vegetable consumption by 6- to 72-month-old children between pre- and postintervention [6]. In the present investigation, a fourfold increase was noted between pre- and postintervention. These results demonstrate that a community-friendly communication strategy can effect an increase in the frequency of intake of carotene-rich foods. Although there were some positive changes in the positive control area, they were not as significant as those in the experimental area. It is possible, however, that the traditional methods of education, if carried out regularly, could influence the intake over time.

The proportion of preschool children in the experimental areas consuming green leafy vegetables at least three times per week was higher than in the other two control areas. Ninety percent of the total retinol intake among the preschool children was from vegetable sources, with or without intervention. The community, obviously preferred vegetable sources because their production was under their control and involved very little effort.

In addition to providing information, changing attitudes is very important for achieving modifications in dietary behavior. Despite awareness about the negative consequences to their health, some individuals are resistant to any change due to illiteracy and ignorance. With appropriate knowledge-based innovative presentation of suitable solutions to generate a process towards opinion change, the present intervention motivated the community to make sustainable decisions. It enhanced the prestige of green leafy vegetables by suggesting that "Among all vegetables, green leafy vegetables are the best." The approach was an integrated attempt to improve the perceptions of the community, simultaneously highlighting feasibility of production of green leafy vegetables at the household level. Subsequently, the theme was shifted to "Foods good for eyes," emphasizing the role of carotene-rich foods in the diets of preschool children and pregnant and lactating women. This phased process of providing the information, based on preliminary research, not only helped to understand the current status and community's perception of carotene-rich foods, but also in taking appropriate action.

It is well known that even if people's attitudes towards a required behavior change are favorable, changing behavior may be impeded by factors such as distance, time, expense, or plain inertia [11]. Even though seeds and seedlings for growing carotene-rich foods had been distributed to households before the current study [9], the community in the positive control area was not as motivated as the experimental community to adopt home gardening.

In order to achieve sustainable progress, there is a need to change the community from passive recipients of health and nutrition to active participants in the developmental process. On the basis of the results of the present study, restructuring the communication process by utilizing marketing tools to bring about social mobilization is a promising approach. The initial cost in terms of time and efforts to mobilize the community might be high. However, considering the effectiveness in motivating the community to modify their dietary behavior, the benefits from the social-marketing program far outweigh the cost.

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# Report of Working Group 1: Promoting the fortification of appropriate foods

Chairperson: Joan Matji, UNICEF South Africa

Fortification of appropriate foods is an important component of a comprehensive food-based approach toward sustainable control of micronutrient malnutrition, particularly vitamin A deficiency disorders. There are several aspects to be considered and issues to be resolved before investing in food fortification. Key issues discussed by participants included the following:

» Need for food-consumption survey data to identify micronutrient problems, target groups for interventions, and appropriate food vehicle(s) that could be fortified, including staple foods, complementary foods, and postweaning foods;
» Importance of evaluating risks of fortification versus doing nothing and communicating information to policy makers and the scientific community;
» Consideration of the potential for use of existing mechanisms and distribution systems for cost sharing and for multiple micronutrient fortification;
» Emphasis on programs that have proven value, e.g., sugar fortification;
» Importance of enhanced private and public sector collaborations and strong multisectoral consultation aimed at empowerment of community development programs—all stakeholders should be involved from the beginning;
» Fortification programs should aim at annual per capita costs in the range of US$0.5–1.0 to keep within affordable economic range of target groups;
» Communication of social and economic benefits needs to be broadly disseminated to decision makers, private sector, and donor community to ensure sustained strong financial and political support for a fortification approach;
» A mechanism for monitoring implementation, progress, and impact is essential.

The working group's recommendations for fortification programs were the following:

» Use a systematic approach to establish the best foods for fortification;
» To minimize costs, use existing infrastructure to deliver fortified food;
» Aim for multisectoral consultation and consensus building at all stages of the program;
» Support all efforts with a communication campaign involving all stakeholders to create a favorable climate for acceptance of the product(s);
» Ensure proper monitoring and enforcement of the program at all stages;
» Demonstrate impact and economic benefit to all stakeholders, especially to policy makers;
» Clearly address issues of costs, benefits, and political commitment to ensure sustainability.

# Report of Working Group 2: Production, conservation, and distribution of foods with vitamin A activity

Rapporteur, Esi Amoaful; Chairperson, Peter T. Ewell

Within the medical and health communities, the promotion of foods that are naturally rich in β-carotene and other sources of vitamin A has a relatively low profile. Many professionals are more comfortable with periodic distribution of high-dose supplements. This lack of interest has limited investment in creative and innovative food-based approaches. In turn this has meant that there are relatively few success stories that have been empirically evaluated and can be used to enhance the profile of this approach.

This meeting has been an excellent catalyst for the promotion of a food-based approach, which we believe is a sustainable way to include vitamin A within broader strategies to improve the nutrition and health of those Africans most at risk. There is an urgent need to build partnerships and both informal and formal networks to share experiences on community-level, food-based actions. This is needed as the basis for advocacy at several levels: within the health and nutrition community, with policy makers in governments and international agencies, and with grassroots organizations, including community-based organizations, women's groups, schools, youth organizations, etc.

The first step is to identify plant and animal sources of vitamin A that can feasibly be promoted and that are acceptable to local tastes and preferences. Key players who have tended to operate separately must be brought together to collaborate in food-based projects. These include agricultural research and extension, public institutions involved with health and nutrition, nongovernmental organizations, and the private sector. The following sources have promise for expanded use:

- Green leafy vegetables, both a wide diversity of indigenous types and imported vegetables, such as cabbage and tomatoes;
- Varieties of crops that are higher in β-carotene than commonly grown types. These include orange-fleshed sweet potato, yellow maize, yellow cassava, red palm oil, selected tomatoes, certain kinds of squash, etc.;
- Fruits, both fresh and sun-dried to extend their availability beyond typically brief harvest seasons;
- Household animals, particularly eggs, chickens, rabbits, etc.

Foods rich in vitamin A should be targeted at those most at risk of deficiency. Special emphasis should be placed on weaning foods and on recipes for preparation in the household, as well as support for projects preparing and distributing foods at the community level. This can complement programs for the distribution of commercially manufactured weaning foods.

The food habits, tastes, and preferences of children should be understood, so that they can be targeted specifically. Other important target groups are schoolchildren, especially adolescent girls, pregnant and lactating women, and people with HIV/AIDS. Any intrahousehold beliefs and practices that tend to restrict consumption by children, pregnant and lactating women, and other vulnerable groups need to be understood and countered.

It should be recognized that fortification programs primarily reach people who purchase commercially processed food. Strategies based on household food production can reach people at risk who subsist at the margins of the cash economy. However, home and community gardens and other production systems require support. This includes the development of systems for the multiplication and distribution of seeds, as well as the nurseries to supply seedlings and cuttings of vegetative propagated crops. Through networking, grassroots organizations can obtain training and training materials and identify sources of extension materials and advice. Poor animal health is a major constraint for small-scale producers. Management advice and inexpensive drugs can have a dramatic impact on household animal production.

Support for production should be directly linked with information and training on health promotion, nutrition, recipes, and simple processing techniques. Where markets can be developed for new products rich in vitamin A, it will not only help alleviate micronutrient deficiency, but also improve the incomes and dietary diversity of the target populations. Technical information on all of these issues should be disseminated widely, to bridge a major information gap.

There is an urgent need to strengthen human resources and institutional capacity for dealing with vitamin A deficiency, building upon and coordinating what already exists in the agricultural, health, and nutrition sectors.

Bioavailability issues are particularly important when promoting a decentralized strategy. This should start with up-to-date information on the content and availability of carotene and vitamin A in foods promoted as sources. Microbial contamination and residues from pollutants and pesticides must be monitored and dealt with, both in the production systems and in subsequent storage and processing.

The issue of crops genetically modified to deliver vitamin A was considered. The long-term potential and possible risks of “yellow rice” and other such innovations are being widely discussed in various forums and in the media. Many partner institutions are wary of getting involved because certain sectors of public opinion are vocally opposed to “tampering with nature.” In discussion, the question was raised of how much time and energy the vitamin A community wants to invest at this time until the much broader debate on bioengineered food has run its course. However, the scientific and factual issues related to bioengineered provitamin A foods must be considered by the nutrition community, because there is tremendous potential for improving the micronutrient content of foods that are consumed on a massive scale. Nevertheless, many conventional crops and animals that are good sources of vitamin A are available right now. In the immediate future there is a need to focus on delivery systems that will get available appropriate foods incorporated into the diets of people most at risk.

The group identified the collection and analysis of good monitoring and evaluation data as a priority. This should include information on the microeconomic costs and benefits of food-based approaches that can be compared with other strategies. Well-documented experiences on the pilot level will encourage grassroots organizations to initiate programs of proven effectiveness. At the same time, we must build in strategies for scaling-up from pilot efforts right from the start, to show that the benefits can reach enough people to have impact commensurate with the scale of the problem. We need evidence that will influence and motivate policy makers at various levels in various institutions to support a food-based approach.

This working group, like the other two, agreed that all three major approaches to overcoming vitamin A malnutrition need to be supported. Supplementation is very important where clinical deficiencies are serious, and it is being combined effectively with vaccination campaigns. The fortification of sugar, fat, and staple grains can reach major sectors of the population, particularly when done at community hammer mills as well as at the industrial level. The promotion of foods rich in vitamin A can be sustained by the beneficiaries themselves and is an important entry point into broader food-security strategies for Africa. In the longer run, it is hoped that genetically engineered foods will make a major contribution.

# Report of Working Group 3: Promoting food-based approaches to eliminate vitamin A deficiency in Africa

Rapporteur, D'Ann Finley; Chairperson, Ian Darnton-Hill

Although malnutrition is a problem in Africa, South Africa and some other African countries are exporters of food. Why, then, is there a problem with malnutrition in general, and vitamin A deficiency in particular, in Africa? The causes of malnutrition can often be traced to limitations in food availability and accessibility and limited behavioral choices.

Food-based approaches offer the opportunity to address all three limitations. Well-designed programs have not only improved accessibility, but through empowering communities, and women in particular, have increased the availability of food to vulnerable groups. It has also been argued that increasing the choice of foods is an important part of development. Therefore food-based approaches are essential.

The holistic nature of the life cycle is an advantage in using it as the basis for promoting a food-based approach to eliminate vitamin A deficiency in Africa. Multigenerational households are common in Africa. The life-cycle approach allows for broader assessment and analysis of possible vitamin A deficiency and allows for linkages to other sectors. This enables integration among programs.

There are also challenges to using the life-cycle approach to promoting the food-based approach to eliminate vitamin A deficiency in Africa. Intrahousehold food distribution does not always result in the individual in most need receiving the vitamin A–rich foods.

Food-based approaches can be linked to other strategies, such as fortification or supplementation. Shortcomings of fortification and supplementation, such as the limited accessibility and availability of fortified foods and the low coverage of supplementation programs in most parts of Africa, make this linkage essential. Synergy among several approaches can result in increased coverage and can often result in increased availability of other resources by eliminating duplication of effort. Success, whether from a single strategy or a combination of several, improves the image of policy makers.

There are, of course, challenges of linkages of a food-based approach with other strategies. Synergy often means working with several departments or bureaucracies, each with its own set of resources. There is the constant need to keep all groups working on the same overall goals and priorities.

A primary characteristic of a food-based approach is the need to link with other programs. Inputs from these programs are necessary for the food-based approach to be successful. For example, seeds suited for the particular ecosystem need to be provided. The programs need to have similar messages. However, linkages to other programs provide multiple opportunities for intervention.

The challenges with working with other programs are to ensure that the individuals involved in the programs understand each other; the goals of each one need to be related to the goals of the other(s). For example, nutritionists interested in eliminating vitamin A deficiency need to be able to express their concerns in terms of the goals of educators—to increase school attendance or achievement. Another challenge is that other programs often do not see food-based approaches as viable.

## Recommendations

All strategies for eliminating vitamin A deficiency should be combined and weighted depending on the specific situation. There needs to be a comprehensive assessment at all levels of the accessibility and behavioral characteristics of the population. It is important to remember that a food-based strategy should result in community empowerment.

# Books received

**Nutrition and immunology. Principle and practices.** Edited by M. Eric Gershwin, J. Bruce German, and Carl L. Keen. Humana Press, Totowa, N.J., USA, 2000. (ISBN 0-89603-719-3) 505 pages, hardcover. US$149.50.

Understanding of the interactions of nutrition and immunology continues to gain in importance and complexity and to offer great promise for preventive and therapeutic approaches to human disease. The enormous amount of clinical and epidemiological data now available confirms that various forms of malnutrition in human populations contribute significantly to morbidity and mortality from disease. The major mechanisms for this relationship are immunological, and progress in understanding them has been rapid in recent decades. It is now possible to assess more closely the nutritional requirements of various aspects of immunity. It has become essential that all being trained in nutrition today as well as those already engaged in nutrition research and practice keep informed of these advances.

Of the recent books designed for this purpose, this text is outstanding. It focuses attention on science issues and provides clear, understandable summaries of the state of current knowledge. It first provides three chapters on nutritional assessment, including one on evaluation of the immune system in the nutritionally at-risk host and eight chapters on the specific nutrient requirements of populations of all ages. These are followed by 26 chapters on specific aspects of nutrition-immune interactions that include both the effects of individual nutrients on immune status and the immunological basis for the effectiveness of breastmilk, adverse reactions to food, the effects of smoking, alcohol, and substance abuse on immune function, and immunizations. Disease-specific chapters deal with obesity, diabetes, HIV, autoimmune disease, cancer, and oral disease. The chapter on nutrition and immunity in aging is an excellent example of the comprehensive and authoritative coverage of the topics listed.

In addition to the traditional tools of nutritional education, it is now possible to redesign the food supply by food technology and genetic manipulation in order to optimize immunological performance. This makes a book on nutrition and immunology of potential value to food scientists and plant breeders as well as nutritionists. Its only drawback is its high price. Permission to copy for personal use is given for US$10.00 plus $0.25 per page.

**World review of nutrition and dietetics. Volume 87: Mediterranean diets.** Edited by A. P. Simopoulos and F. Visioli. Karger, Basel, 2000. (ISBN 3-8055-7066-X) 184 pages, hardcover. CHF 228.–/DEM296.–/ US$198.25.

This slender book makes it clear that there is no such thing as one Mediterranean diet. The region includes nations with varied cultures, traditions, incomes, and dietary habits and patterns, and these are changing with the impact of economic development and globalization. The book describes, in separate sections, differences in diets among countries in the Mediterranean region. However, it also indicates that a balanced ratio of n3 and n6 omega methyl fatty acids and a high antioxidant intake from fruits and vegetables, along with the use of olive oil, contributes to a lower rate of heart disease and cancer and increased longevity.

The traditionally higher physical activity of Mediterranean populations does not receive attention. However, a key chapter reports on the favorable results of a randomized, single-blind secondary prevention trial aimed at testing whether an experimental diet modeled after that of Crete can reduce the risk of recurrence after a first myocardial infarction. This trial controlled for other known factors. The book also examines the antioxidants, the composition of fats, and the use of olive oil and wine in Mediterranean diets.

This book is well worth consulting in libraries, but its purchase price will be hard for individuals to justify.

**Zinc and human health: Results of recent trials and implications for program interventions and research.** Edited by Kenneth H. Brown and Sara E. Wuehler. International Development Research Centre, Ottawa, Canada, 2000. (ISBN-894217-13-6) 68 pages, paperback. CAD$15.00.

This report is based on a conference on “Zinc and human health, results of recent intervention trials and implications for programmatic interventions and program-linked research” held at the University of California Davis in 1999. The first part contains background information on zinc nutrition and its relationship to human health, and the second presents recommendations of the discussion groups. Substantive research contributions were published in the *Food and Nutrition Bulletin*, Volume 22 (June 2001). This publication provides an inexpensive update on an area of human nutrition of growing importance.

# News and notes

## IX Asian Congress of Nutrition

The IX Asian Congress of Nutrition, sponsored by the Federation of Asian Nutrition Societies, the Nutrition Society of India, and the Nutrition Foundation of India, will be held February 23–27, 2003, in New Delhi, India. The theme of the Congress is "Nutrition Goals for Asia-Vision 2020," with the following prime objectives:

» To promote awareness of the latest advances in nutrition sciences among scientists and policy makers in order to facilitate nutrition development;
» To compare country experiences with respect to programs for the improvement of nutritional status of populations;
» To identify procedures for encouraging community participation in nutrition programs;
» To promote the importance of optimal utilization of locally available foods for combating malnutrition;
» To promote the practice of scientific dietetics in the hospitals.

Contemporary nutritional issues facing Asia and frontier areas such as biotechnology, molecular biology, and advances in nutritional sciences will be covered in 8 plenary sessions, 35 symposia, 20 free communication sessions, and 4 poster sessions. For more information contact Dr. C. Gopalan, President, IX Asian Congress of Nutrition, Nutrition Foundation of India, C-13 Qutab Institutional Area, New Delhi 110016, India; tel. 91 11 6857814, 6962615; fax 91 11 6560106, 6857814; e-mail: acn2003@yahoo.com; website: www.acn2003india.net.

## IUNS Award

The International Union of Nutritional Sciences (IUNS) award, sponsored by the International Nutrition Foundation, was presented to Dr. Rajammal P. Devadas in recognition of her outstanding contributions to women's education and community nutrition programs in India and inspired leadership in nutrition on August 29, 2001, during the 17th International Congress of Nutrition held in Vienna, August 27–31.

# Editorial Announcement

All manuscripts submitted to the Food and Nutrition Bulletin after January 1, 2002 will be subject to a charge of US$60.00 per printed page. It is assumed that this will be paid by the funding source for the study submitted. In the case of developing country authors whose research did not have sponsorship able to pay this charge, the page charge may be waived. An affidavit to this effect will be required. Studies acknowledging major financial sponsors will not be eligible for waivers. For the cost of special issues or supplements, the editorial office should be consulted.

Beginning immediately, we ask all authors who can to submit their manuscripts electronically, but tables and figures should not be imbedded in the text. In addition one hard copy of the manuscript and the original figures should be forwarded by mail.

The Bulletin welcomes paid announcements of appropriate professional opportunities, courses, and publications. To arrange for these contact the editorial office.

*In Memoriam*

# William J. Darby, M.D., Ph.D., 1913–2001

Another of the outstanding leaders responsible for the recognition of nutrition as a disciplinary and interdisciplinary science of major importance for human health and welfare, William J. Darby died on June 6, 2001, at his home in Nashville, Tennessee. He had been suffering the consequences of multiple strokes. He graduated in medicine from the University of Arkansas in 1937 and received his Ph.D. in biochemistry from the University of Michigan in 1942.

Throughout most of his professional career, he was Professor of Biochemistry and Director of the Division of Nutrition at Vanderbilt University. From 1972 to 1982, he served as President of the Nutrition Foundation founded by Charles Glen King. During his tenure, the Foundation sponsored many international meetings on nutrition issues, supported young investigators, financed nutrition research projects internationally, and published 16 monographs on nutrition as well as the monthly *Nutrition Reviews*.

His major scientific contributions to nutrition include the demonstration that folic acid corrects the macrocytic anemia of nontropical sprue; studies of nutrition and pregnancy, iron absorption in children, and iron metabolism of pregnant women; nutrition in ancient and modern Egypt; pellagra in Yugoslavia; and the nutrition surveys in many countries carried out under the auspices of the Interdepartmental Committee on Nutrition for National Development (ICNND). As Chairman of the Technical Advisory Committee of the Institute of Nutrition of Central America and Panama (INCAP) during its formative initial years from 1950 to 1960, he had a major impact on its successful development.

He was the driving force in the creation and activities of the Food Protection Committee of the US National Research Council and led it with energy and vision for 17 productive years. He was also a major contributor to the Council on Food and Nutrition of the American Medical Association and to many activities of the US Food and Nutrition Board. Some his most important international contributions came through his participation in or chairing of many WHO and WHO/FAO expert committees and consultations. He also obtained support for long-term nutrition field studies in Egypt and published a book on food customs of ancient Egypt, *Food: the Gift of Osiris*, with the Egyptian endocrinologist Paul Ghalioungui. He was an active member of the Committee on International Research and Training of the US National Institutes of Health and contributed to its annual evaluation visits to five overseas sites.

After retiring from the Nutrition Foundation and returning to Nashville, he dedicated his energies to building a history of nutrition collection as his legacy to Vanderbilt and scoured the world for the original texts of relevant publications. His exhibits on the history of nutrition at the annual meetings of the American Institute of Nutrition are legendary, and he was responsible for establishing History of Nutrition Symposiums at these meetings. He received many well-deserved honors and recognitions, but particularly prized his election to the US National Academy of Sciences in 1972.

An outstanding personal characteristic was his generosity in encouraging and supporting younger investigators as well as his sacrifices to serve actively and wholeheartedly on review boards, panels, and editorial and advisory committees related to nutrition both national and international. One notable time he was still working on the report of the Technical Advisory Committee in INCAP when his name was called by the President of Guatemala at a National Palace reception to receive its highest award to a scientist, the Robles Medal. Throughout he received strong support from his wife Elva, who often accompanied him on his international travels. His influence on and contributions to the major food and nutrition issues will be greatly missed, as will his positive, critical, constructive, and multifaceted approach to nutrition issues worldwide. Younger and older scientists alike have lost a good friend. Besides his wife, he leaves three sons, William J., James Richard, and Thomas Douglas.

*Nevin S. Scrimshaw*

## Note for contributors

The editors of the *Food and Nutrition Bulletin* welcome contributions of relevance to its concerns (see the statement of editorial policy on the inside of the front cover). Submission of an article does not guarantee publication—which depends on the judgement of the editors and reviewers as to its relevance and quality. All potentially acceptable manuscripts are peer-reviewed. Contributors should examine recent issues of the *Bulletin* for content and style.

*Language.* Contributions should be in English.

*Format.* Manuscripts should be typed or printed on a word processor, **double-spaced**, and with ample margins. Only an original typed copy or a photocopy of equivalent quality should be submitted; photocopies on thin or shiny paper are not acceptable.

When the manuscript has been prepared on a word processor, a diskette should be included with the manuscript, with an indication of the disk format and the word-processing program used. To the extent possible, manuscripts should be submitted electronically.

*Length.* Ordinarily contributions should not exceed 4,000 words.

*Abstract.* An abstract of not more than 150 words should be included with the manuscript, stating the purposes of the study or investigation, basic procedures (study subjects or experimental animals and observational and analytical methods), main findings (give specific data and their statistical significance if possible), and the principal conclusions. Emphasize new and important aspects of the study or observations. Do *not* include any information that is not given in the body of the article. Do not cite references or use abbreviations or acronyms in the abstract.

*Tables and Figures.* Tables and figures should be on separate pages. Tables should be typed or printed out double-spaced. Submit only original figures, original line drawings in India ink, or glossy photographs. Labels on the figures should be typed or professionally lettered or printed, not handwritten.

*Photographs.* Ideally photographic materials should be submitted in the form of black and white negatives or black and white glossy prints. Photographs will not be returned unless a specific request is made.

*Units of measurement.* Preferably all measurements should be expressed in metric units. If other units are used, their metric equivalents should be indicated.

*Abbreviations.* Please explain any abbreviations used unless they are immediately obvious.

*References.* References should be listed at the end of the article, also double-spaced. Unpublished papers should not be listed in references, nor should papers submitted for publication but not yet accepted.

Number references consecutively in the order in which they are first mentioned in the text. Identify references in the text and in tables and figure legends by arabic numerals enclosed in square brackets. References cited only in tables or figure legends should be numbered in accordance with the first mention of the relevant table or figure in the text. **Be sure references are complete.**

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—*corporate author:*

2. Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gammaglutamyltransferase in blood. Scand J Clin Lab Invest 1976;36:119–25.

*Book or other monograph reference*

—*personal author(s):*

3. Brozek J. Malnutrition and human behavior: experimental, clinical and community studies. New York: Van Nostrand Reinhold, 1985.

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4. American Medical Association, Department of Drugs. AMA drug evaluations. 3rd ed. Littleton, Mass, USA: Publishing Sciences Group, 1977.

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5. Medioni J, Boesinger E, eds. Mécanismes éthologiques de l'évolution. Paris: Masson, 1977.

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