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Improved Solar Drying of Vitamin A-rich Foods by Women's Groups in the Singida District of Tanzania

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Introduction

Many at-risk populations in developing countries are deficient in iodine, iron, and vitamin A, making them more vulnerable to illness, fatigue, blindness, and memory loss, and increasing the possibility of mental retardation among their children. Enhancing these micronutrients can result in improved well being and physical development. Infants and pre-school children would have greater chances of survival, better health, and increased intellectual capacity. Women could have improved pregnancy outcomes and increased productivity. Supplementation, food fortification, dietary diversification, nutrition education, and food production are strategies that have been developed to reduce these micronutrient deficiencies, and have, for the most part, demonstrated positive, though uneven, results. For instance, recent data indicate progress worldwide in combating vitamin A deficiency; however, subclinical deficiencies of this micronutrient remain uncontrolled. Further, iron deficiency anemia continues to affect as many as 43 percent of women and 34 percent of men globally with widely divergent regional differences in rates (ACC/SCN 1997). In order to virtually eliminate vitamin A deficiency by the Year 2000, and to reduce iron deficiency anemia among women of reproductive age and young children by one-third of 1990 levels, continued efforts must be made to strengthen and enhance intervention strategies.

The International Center for Research on Women (ICRW), a nonprofit policy research institution that promotes economic and social development with women's full participation, attempted to address these issues through a two-year intervention research program implemented in five countries. Working with partners in Ethiopia, Kenya, Peru, Tanzania, and Thailand, ICRW undertook a series of studies to explore ways to strengthen women's contributions to reducing iron and vitamin A, and to a lesser extent, iodine, deficiencies by combining women's productive and reproductive activities. The idea was to tap into women's roles as income earners and food producers on the one hand, and as food processors and care givers on the other. Community members, particularly women, drew on their knowledge and experiences to develop and implement solutions to micronutrient deficiency problems in their communities. The studies were supported by the Opportunities for Micronutrient Interventions (OMNI) Research Project, managed by the International Life Sciences Institute (ILSI), and funded by the United States Agency for International Development (USAID).

The studies were conducted in Ethiopia, Kenya, Peru, Tanzania and Thailand. In **Ethiopia**, the goal was to improve vitamin A status among women and young children. It built on the achievements of a previous dairy goat project designed to improve household income and well being by increasing women's assets. The current study expanded the technology package of the earlier project to include interventions specifically aimed at reducing constraints to vitamin A intake. This included increasing health and nutrition knowledge, expanding access to seeds, improving skills at food production, particularly through home and school gardens, and processing, and increasing vitamin A intake of young children and women.

In **Kenya**, an intervention research project introduced new varieties of sweet potatoes rich in beta carotene to women farmers. The Kenya Agriculture Research Institute provided planting materials and agricultural extension agents trained women in methods for growing and harvesting the sweet potato, post-harvest processing and preparation techniques. In addition, health and nutrition education sessions were conducted to heighten awareness of the contribution vitamin A makes to children's health and development, and to encourage consumption of food products using the new sweet potato variety. The intention was to create supply and demand for the new food products — in the household and for market sales.

In **Thailand**, the research team built on experiences from an earlier social marketing intervention that increased production and consumption of the ivy gourd plant and other foods rich in vitamin A. Women leaders in their communities were trained in problem-solving methods and community mobilization techniques. The women then organized their communities to develop and implement plans of action to improve iodine, iron, and vitamin A status. The project provided small seed grants to support the costs for implementing some of the community-based actions, including food production, local preparation and sale of iodized salt, and health and nutrition education.

The **Peru** study was designed to explore the use of participatory methodologies to engage women members of community kitchens in peri-urban Lima in the design, implementation, and evaluation of a trial intervention to reduce iron deficiency among women of reproductive age. The intervention trial focused on improving the quality of service in terms of nutritional content of meals and management practices, such as instituting quality assurance checks on meal preparation and kitchen hygiene, and stimulating demand for these innovations through health and nutrition education.

This report summarizes the findings from the intervention research project implemented from 1995-98 in **Tanzania** by the Tanzania Food and Nutrition Centre (TFNC). The focus of the study was to promote the adoption of improved home-based solar dryers as a means to enhance nutritional quality of vitamin A-rich foods and consumption of those foods by young children. The dryers were adapted from earlier models based on women's suggestions to provide options in terms of dryer size and construction materials. Community members provided all the materials for constructing their household dryers. Local artisans were trained to assist household members in constructing and maintaining the dryers. Nutrition and health education was used to stimulate demand for the dryers and consumption of the nutritionally improved, value added dried foods. Women were trained in business management practices to enhance their net income through marketing vitamin A-rich dried food products.

Background

The problem of vitamin A deficiency (VAD) in Tanzania was first assessed in the early 1980s using a hospital-based sentinel surveillance system for xeropththalmia (Foster et al. 1986). Community-based surveys conducted in the late 1980s suggested that VAD was a problem of public health significance in Tanzania (Pepping et al. 1988). Data collected by the Tanzania Food and Nutrition Centre (TFNC) suggests that xerophthalmia leads to between 2,000 and 4,000 new cases of blindness every year, so that, at any one time, as many as 10,000 children are likely to be suffering from nutritional blindness (TFNC 1990). It is further estimated that VAD and xerophthalmia affect about six percent of the Tanzanian population and 98 percent of these are children under six years of age. This means that about one out of every three children under six are affected by the problem.

Although vitamin A deficiency has been found in most agro-ecological zones of Tanzania, subclinical cases of the deficiency are more prevalent in the drought prone areas of the country due to limited availability and consumption of vitamin A- and provitamin A-rich foods, particularly vegetables and yellow fruits, during the dry season. In Singida, a dry area in central Tanzania, results of several community-based surveys support this relationship. In a survey conducted during the 1991 dry season (October-November), 60 percent of 226 children less than six years old had serum retinol levels less than 20 micrograms/decilitre (mcg/dl) and 15 percent were severely deficient (serum levels less than 10 mcg/dl) (Mselle and Temalilwa 1993). A second study conducted during the rainy season (December) of the same year found that, of 250 children, 35 percent were vitamin A deficient and three percent were severely affected (Kavishe 1993). A final study conducted during the rainy season (March-April) in 1993 found a slightly lower prevalence of VAD, that is, 27 percent of a total of 238 children were VAD with approximately one percent severely deficient (Mselle and Temalilwa 1993).

The government of Tanzania has promoted a range of interventions to reduce vitamin A deficiency. These include information-education-communication (IEC) programs to increase awareness and knowledge of the problem, its causes and solutions; promotion of red palm oil with marketing in the southern highlands; production of vitamin A-rich foods in home gardens; and universal capsule distribution to children less than two years old and to women within four weeks post-partum.

Recognizing that a constraint to using food-based interventions in rural areas in Tanzania is the limited supply of vitamin A-rich foods (particularly fruits and vegetables), TFNC, in collaboration with the Ministry of Agriculture, initiated a horticulture pilot project in 1992. The project mobilized community leaders and farmers to establish vegetable gardens and plant fruit trees in five randomly selected communities in the Ilongero Division of the Singida Rural District. Indigenous dark green leafy vegetables, such as amaranth, sweet potato leaves, cowpea leaves, and *maimbe*, and such fruits as papaya, mango, and guava were promoted in the production-focused project. Farmers purchased seedlings at a subsidized rate from nurseries prepared by agricultural extension agents. These agents also provided technical support in planting, caring for, and harvesting the fruits and vegetables. As a result, there was an increase in production of the promoted plants, although severe droughts beginning in 1995 and seasonal water shortages impacted on yields.

An equally important effort to provide year-round sources of vitamin A in Tanzania has been the focus by government and other agencies on improving preservation techniques for vitamin A-rich foods. The most common traditional food preservation method used in Tanzania is sun drying. Foods are placed on mats or the bare ground, primarily by women, and exposed to direct sunlight. While limited inputs are needed to use this technique (principally, the food source

and women's time), the technique carries high risks of contamination by dust, birds and other animals and insects, and it changes the natural colors of the unprocessed food products, making it undesirable to some consumers. Further, traditional drying results in excessive losses of carotenoids due to the vulnerability to oxidation that is accelerated by oxygen, ultra violet and visible light, heavy metals, and high temperatures (Clydesdale 1991).

To address these issues, improved solar dying methods have been developed and introduced to rural communities worldwide. Compared to sun drying, improved enclosed solar drying provides high air temperatures and consequential lower relative humidities leading to improved drying rates and a lower final moisture content of the dried crop. As a result, the risk of spoilage during the drying process and in subsequent storage is reduced (ILO 1978). Drying in an enclosed structure has the additional benefit of providing protection against rain and contamination. All these factors contribute to an improved and more consistent product quality with increased market value.

In Tanzania, as in other African countries, women are generally responsible for food processing activities. Appropriate technologies have long been an accepted means to increase women's efficiency and productivity, and improve household food security (FAO 1959; Huffman in Gittinger et al. 1987; ECART 1994). This is critical given that women can spend on average 15 hours per day in productive activities (Rutahakana et al. 1991). In this study, the solar dryers have the potential of increasing efficiency and productivity, with the additional advantage of increasing availability of vitamin A-rich food sources. Thus, it makes sense that the technology be targeted to women—given their roles as food processors, caregivers, and income earners—and that other community members be drawn into the process to support women in their decisions and actions.

Improved enclosed solar drying was first introduced to the Singida area in 1992 by TFNC in collaboration with the USAID-supported Vitamin A Field Support Project (VITAL) (Mgoba et al. 1993; Linehan 1994). The technology had been tested in Haiti and the Dominican Republic for drying mangoes and was found to be generally effective and acceptable by community members. The 1992 Tanzania project trained local carpenters in the construction of wooden dryers for community use. Women group leaders from five communities were invited to view the construction of the dryers and were trained in preparing foods for drying and proper drying and storage techniques. At the end of the training, dryers were donated to the women (two dryers per community) for communal use. The women leaders were urged to train other women in using the new dryers and constructing more of them.

Two years later, the technology had not diffused beyond the original communities nor had any additional dryers been constructed in these communities. This was attributed to the lack of individual ownership reducing the incentive to maintain the communally-operated dryers; the large size of the dryers making them less amenable for household use and expensive to build and maintain; and the low level of awareness of the advantages of the technology over traditional drying processes. The conclusion was that the process of introduction limited its eventual adoption.

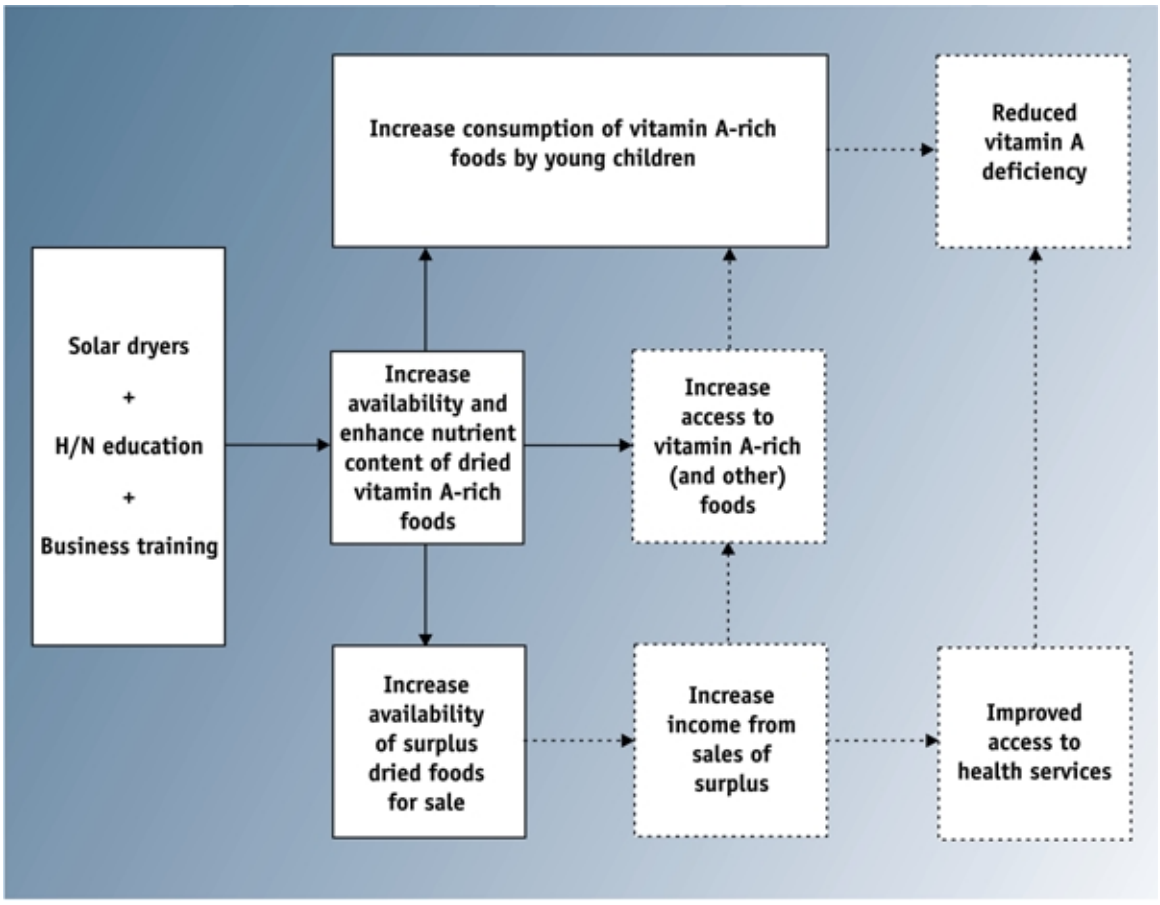
Conceptual Framework

This report presents the findings of an intervention research study conducted from 1995-98 in the Ilongero Division of the Singida Rural District, the same area in which the horticulture and VITAL projects were undertaken. The study was implemented by the Tanzania Food and Nutrition Centre in partnership with the Ministry of Agriculture's extension service, the Ministry of Health, and with community members. To encourage the construction and use of the enclosed solar dyers, the technology was adapted to meet women's expressed preference for smaller, home-sized dryers and provide a choice of dryer construction — wooden or mudbrick. This technology introduction was complemented by community-wide health and nutrition education and business management training for all women in the communities. The focus of the study was to promote the adoption of improved home-based solar dryers as a means to enhance nutritional quality of vitamin A-rich foods and consumption of those foods by young children (12-71 months of age).

The conceptual framework that guided the design, implementation, and evaluation of the study is shown in Figure 1.

The framework speculates that an intervention package that includes three critical components— improved solar dryers, health and nutrition education, and business training— will eventually

Figure 1. Conceptual framework: Linking solar dryers, nutrition education, and business training to vitamin A intake



lead to improved vitamin A status of young children. While women have traditionally used open-air, direct sun-drying methods to extend availability of seasonally available foods, the improved solar dryers would reduce losses due to contamination and improve the nutritional quality of the dried foods. The health and nutrition education component would stimulate both the construction of the new dryers and feeding of the dried foods to young children. Business management training would encourage women to dry a surplus of fresh foods and sell them, thereby increasing their income. The earned income would be used to purchase foods and other services that would improve the health and nutrition of the young children.

Study Objective and Design

The study's main objective was to increase children's (12-71 months old) consumption of vitamin A-rich dried (and fresh, as appropriate) foods. The specific objectives of the study were:

- To monitor the adoption rates of the improved enclosed solar drying technology;
- To determine women's perceptions of the nutritional and economic benefits of using the improved solar dryers for processing vegetables;
- To estimate the income-generating potential of the improved solar dryers;
- To assess the nutritional quality of the dried products;
- To measure changes in the frequency of consumption of vitamin A-rich foods among children under five years; and
- To promote the adoption of the study's results among relevant decision-makers.

The study's hypotheses were that improved enclosed solar drying of vitamin A-rich foods to enhance nutritional quality and nutrition education would significantly increase the consumption of vitamin A-rich foods, thereby alleviating seasonal vitamin A deficiency; and that sale of dried fruits and vegetables would increase women's income, also leading eventually to the alleviation of vitamin A deficiency.

The study was designed to explore the effects of a technology package (dryers plus education plus business management training) on vitamin A dietary intake of young children. The package was aimed at all community members and especially at women.

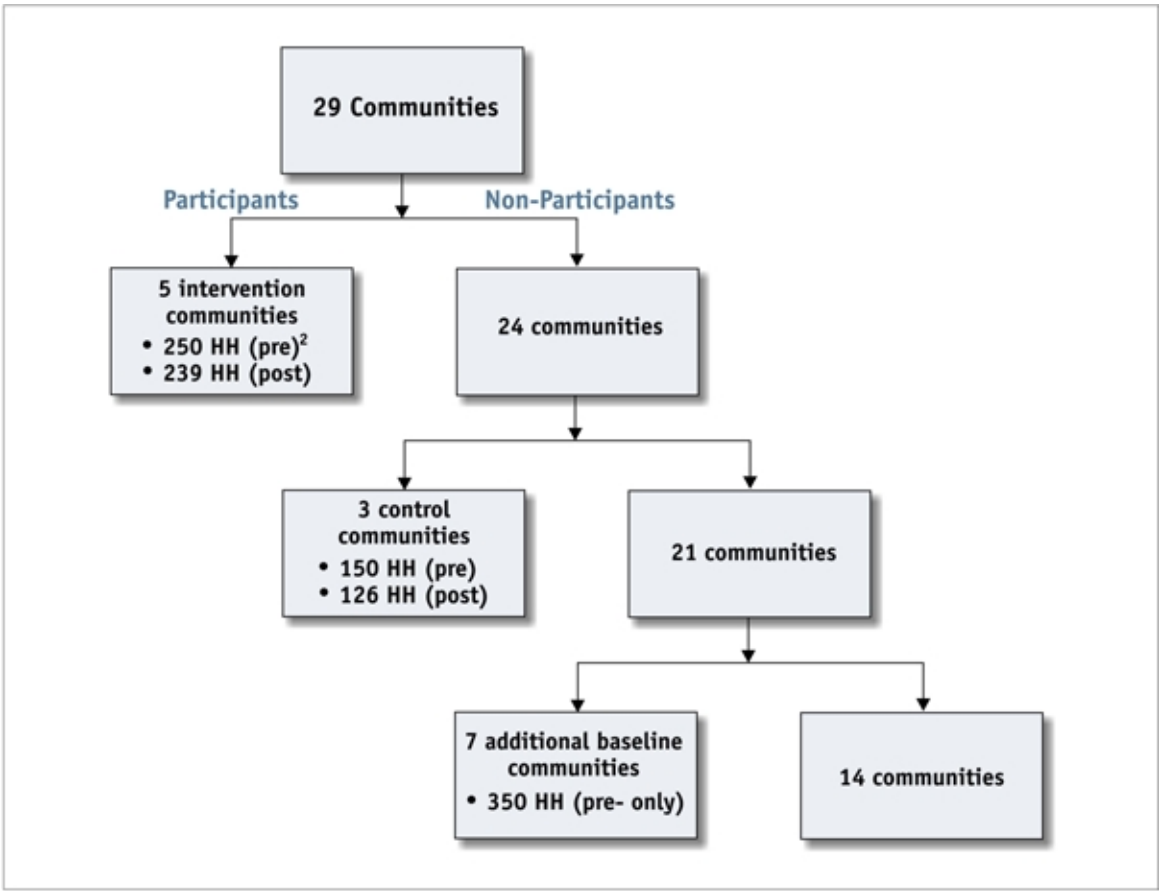
Methodology

The intervention began with a community-wide one-day meeting that introduced the improved dryers, pointing out their benefits over traditional drying and the older solar dryer model in terms of labor and time demands, costs, and nutritional quality of the dried foods. Two demonstration dryers (one mudbrick and one wooden) were constructed in each of the five intervention communities. The health and nutritional benefits of the dried foods also were shared with the participants. Only women participated in a second day that focused on how to use the improved solar dryers, and how to prepare foods for drying and cooking including the use of cooking oil. Women also were invited to participate in a one-day business management training. Local artisans and carpenters (men only) were trained in construction and maintenance of the two types of dryers. Actual construction of the dryers followed the awareness raising, skill-training sessions. Advocacy activities were designed and implemented toward the end of the intervention period to promote long-term institutional support for promoting solar drying technologies.

Sample Size

The study took place in eight randomly selected communities— five intervention and three control (see Figure 2)—in the Ilongero Division of Singida District of Tanzania. The five intervention communities were the same communities that

Figure 2. Sampling scheme, Ilongero Division, Singida Rural District[1]



[1] *All sampling was random.*

[2] *HH stands for households.*

participated in the horticulture project begun in 1992 (see p. 5). Using nonreplacement sampling, three control communities were randomly selected from the remaining 24 (of 29) communities in the study region. An additional seven communities (of the remaining 21) were randomly selected and included in the baseline assessment to examine the likelihood of vitamin A deficiency problems in the area.

In the intervention communities, 250 households were randomly selected at the beginning of the study based on their having a child between the ages of 12 and 71 months old in residence. Post-intervention data were collected on 239 of these households (only 4 percent loss to follow up). In the control communities, pre-intervention data were collected from a randomly selected sample of 150 households with similarly aged children. Post-intervention data were available for 126 of these households (16 percent loss). To facilitate a more detailed picture of the effects of the dryers' adoption on dietary intake of vitamin A, 36 households in the intervention community that had baseline data and that adopted the dryer technology were compared to 174 households that did not adopt the technology.

Data Collection and Analysis

Data were collected during the dry season, before and after the intervention period, when fresh fruits and vegetables were least likely to be available and dried food products more available. Data were also collected on a monthly basis during the routine visits of the agriculture and livestock field extension officers to the intervention communities. These data included the number of new adopters, type of dryers constructed, frequency of weekly use, problems encountered, and solutions employed. Throughout the intervention process, TFNC researchers conducted focus group discussions and key informant interviews with women and other community members to assess knowledge and attitudes about the new technology.

Household surveys were conducted to collect information on household demographics, vegetable availability, food drying practices, income-generating activities, and household expenditures. A market survey to determine availability of dried foods and anthropometric measurements (e.g., weight and height) of women and children 12-71 months of age were undertaken at baseline only.

The beta carotene content of vegetables was determined using high performance liquid chromatography (HPLC) techniques. Samples of seven types of vegetables were blanched in boiling water before they were divided into three lots. The first lot served as the control and was not dried. The second was dried in the open sun following the traditional practice used in these communities, while the third was dried in the improved enclosed solar dryer. All three lots were stored under cold conditions for later HPLC analysis.

The study used the Helen Keller International (HKI) food frequency method[1] to assess community risk of vitamin A deficiency (establishing prevalence) as well as to compare vitamin A consumption before and after the intervention (Rosen, Haselow, and Sloan 1993).[2] Following the HKI guidelines, risk assessment data were collected in 15 of 29 communities in the Ilongero Division of Singida District. Interviews were conducted in 50 households (with mothers of a child between 12 and 71 months old) in each of the 15 communities (total of 750 interviews). HKI scores of the children were aggregated and a community score was calculated. According to the method, if 11 of the 15 communities had food frequency scores less than 6.0, then vitamin A deficiency is a public health problem in the area.

The study also used the HKI score as the main outcome variable for assessing changes in frequency of vitamin A-rich food consumption due to the intervention. Earlier research had validated the method against serum retinol values (Persson

[1] This method yields scores that reflect the number of days per week children < 5 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 of vitamin A deficiency.

[2] Biochemical indicators were not used due to funding constraints.

et al. 1998). Thus, it was presumed that a positive change in the scores would suggest a reduction in vitamin A deficiency. Although the adopters and non-adopters in the intervention communities would be self-selected and results from them could not be extrapolated because they do not represent the communities as a whole, the findings do provide insight into the optimal level of nutritional outcomes that could be achieved by adoption of the enclosed solar drying technology in combination with nutrition education. The main comparisons in this study were three fold: first, within communities (that is, before and after); second, between the five intervention communities and the three controls; and finally, between adopters and nonadopters in the intervention communities.

The nutrition outcome (increased HKI food frequency scores among children 12-71 months old) was expected to be higher among the intervention communities than the controls for two reasons. First, because the nutrition education messages would be widely diffused by the end of the intervention period, most families would have been exposed to the promotional nature of those messages and, therefore, children would be fed more beta carotene-rich foods. A second and smaller effect within this main comparison would be that the adopters of the new technology would have an improved way to dry vitamin A-rich foods that would reduce losses or waste and would enhance retention of carotenoids.[3] This mechanism would contribute to availability (and quality) of those foods and, therefore, their children's dietary intake of vitamin A would increase.

The effect of the business training component of the intervention package on changes in dietary intake was not expected to contribute to the post-intervention scores. This component of the intervention package was aimed at providing women with skills that would, most likely, occur in the long term, not within the timeframe of this study.[4]

[3] This was likely to be a smaller effect if only a small proportion of the sample adopted an improved enclosed solar dryer within the 18-month intervention period, according to previous research on rates of adoption.

[4] Epi Info version 6.0 and SPSS/PC+ were used for analysis of categorical data – Chi squared analyses, and for continuous data – t-tests or non-parametric methods, e.g., Mann-Whitney (Wilcoxon), as appropriate.

Intervention

The intervention consisted of activities that promoted the adoption of the improved solar dryer and consumption of dried vitamin A-rich foods by young children. Business management training sessions were undertaken after health and nutrition education sessions for women and training sessions for artisans and carpenters in construction and maintenance of the dryers. Dryer construction began after all these sessions were completed. The timeframe for selected activities is shown in table 1.

Improved solar dryers

Two new solar dryer designs were developed based on lessons learned by TFNC from earlier solar dryer promotion in the area and on input from community women. One dryer was principally made from wood, which is lightweight and, therefore, portable, enabling women to position the dryer to maximize trapping solar energy at different times in the day (enhancing its effectiveness). It was, however, somewhat expensive. The other dryer was mudbrick and less expensive than the wooden dryer (see photograph on cover and on page 14). The heat retention of this dryer was enhanced by the thickness and poor heat conduction of the brick walls, thereby contributing to its drying effectiveness. However, this dryer was prone to deterioration over time even though the outer walls were coated with used motor oil to reduce rain damage.

Women chose the dryer they wanted to construct and provided all materials needed for the construction. Bulk purchasing of black cloth or plastic sheeting for the dryers was facilitated by TFNC to reduce the unit cost. The cost of materials and labor[5] of the artisan or carpenter for a wooden dryer was approximately 8000 Tanzanian shillings (US$12). Mud-brick dryers cost less than

Table 1. Timeframe for selected activities

Activity	Season	Time frame
Baseline survey	Dry season	October 1995
Introduction of solar dryers in 5 intervention communities ◆ Awareness creating meetings with community, government leaders, men, and women ◆ Nutrition education seminars for women only ◆ Training of 6 carpenters and 6 masons	End of rainy season	April 1996
Business management training for women in 5 intervention communities	Dry season	July 1996
Construction of the dryers begins	Dry season	August 1996
Advocacy and follow-up meetings with communities and ward leaders	Rainy season	February 1997
Additional training of 5 carpenters and 5 masons	Rainy season	March 1997
Final evaluation	Dry season	October 1997

[5] Other indirect costs, e.g., individuals' time and transportation, are not factored into these prices.

half this amount (3500 Tanzanian shillings or US$5)[6]. Annual maintenance costs would be approximately US$2 for plastic sheets (black or transparent) and wire mesh for the drying tray. Once the materials were procured, a dryer could be constructed in one day.[7] While the women or other household members did not construct the dryers themselves (actual construction was done by the carpenters or artisans), they worked alongside those technicians to learn the process and techniques of dryer construction. However, because the dryers' design and construction is relatively simple, artisans and carpenters are not required to build the dryers. The involvement of these technicians in this study was to enhance the diffusion of the dryers and to provide technical support for the adopter households.

Both types performed equally well for drying vegetables. Each dryer could produce approximately 1.5 liters of dried vegetables, if the vegetables were thinly spread to facilitate faster drying. On average, the dryers were used three times a week, with drying times ranging from four to six hours per use, depending on the type of vegetable and intensity of the sun. For example, it would take about four hours to dry amaranth (*mchicha*) leaves on a sunny day, but six hours for sweet potato leaves. Drying one kilogram of fresh vegetables would yield approximately 250 grams of the dried food product.

Promotional and technical support was provided by agricultural extension workers, the project-trained artisans and carpenters, and local community executive officers.[8] The extension agents made home visits to encourage construction, use, and appropriate maintenance of the improved enclosed solar dryers; to discuss any problems the owners had with the dryers or with food preparations; and to record the adoption process, including frequency of use and amounts and type of fresh produce dried. Local artisans and carpenters assisted their fellow community members in the construction and maintenance of the improved enclosed dryers. A total of 11 carpenters and 11 masons were trained in solar dryer construction and maintenance.

Project funds were used as incentives to extension agents, to communities and households, and to artisans and carpenters. Extension agents received fuel allowance to visit the adopter households (approximately 15,000 Tanzanian shillings or US$23 per month). Communities that had the highest number of adopters received a promotional incentive of 20,000 Tanzanian shillings (approximately US$31) and those that had the best artisans (measured by the number of dryers constructed) received 10,000 Tanzanian shillings (approximately US$15). Artisans and carpenters received a small cash incentive of 500 Tanzanian shillings (approximately 80 cents in US currency) to make home visits and to assist as needed.

Health and Nutrition Education

Community-based health and nutrition education meetings were held in each of the five intervention communities for two reasons:

- To raise awareness of vitamin A deficiency and how adoption of improved solar dryers could contribute to year-round availability of vitamin A-rich foods; and

[6] These costs are comparable to the market value of 7 chickens or a bag of maize (for the wooden dryer). 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).

[7] 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 6^0 to capture more sunlight. The mud brick dryer's dimensions were: height at the back, 20 cm; height at the front, 30 cm; width, 80 cm; length, 100 cm.

[8] Community executive officers are paid public sector employees who live in rural communities and are responsible for coordinating and supporting all development activities with their communities.

- To promote young children's consumption of vitamin A-rich foods.

Two one-day sessions were led by TFNC staff; the regional nutrition officer; and agricultural, community development, and health and nutrition extension agents. All community members including local political, religious, and traditional leaders (men and women alike) were invited to attend the first session. The second session was offered to women only.

The first session focused on sensitizing participants to the problem of vitamin A deficiency; its prevention, control, and treatment (such as food production and consumption, and vitamin A capsule distribution); and the contribution that improved solar dryers could make to alleviating this community problem. Participation ranged from 50 to 120 persons depending on the community. Ninety-six or 77 percent of the community leaders attended this session. The session was critical for gaining community leaders' and husbands' support for women's participation in the trial intervention and for eventual adoption of the technology and education messages.

A total of 300 women from the five intervention communities attended the second one-day session. This session provided additional information on vitamin A deficiency and locally available vitamin A-rich foods were identified. Appropriate food storage, handling, and preparation techniques were discussed, including the use of cooking oil in preparing vitamin A-rich dried food products and the use of these products to enrich weaning foods. The advantages of the improved solar dryer over the traditional drying methods in terms of time and labor demands and food quality were presented, and use of the dryer was demonstrated. These messages were reinforced during the agricultural extension agents' home visits to adopter households.

Business Management Training

One-day business management training seminars were conducted in each of the five intervention communities. While open to any community member, these seminars targeted women. The trainer for this session was the Singida Regional agricultural economist working with two TFNC staff. The objective was to train women in basic business practices related to the marketing and sale of food products. Concepts in product presentation, promotion, and pricing were included, with specific focus on ensuring that the packaging was attractive to customers. Women also learned appropriate techniques for producing large volumes to generate sufficient income, developing varieties of products to attract a range of customers, and ensuring quality control of the commercial food products.

A number of marketing techniques to maximize sales and revenues were presented and discussed with the women. These included using sign boards and displays in neighborhood shops or strategic points visited by potential customers and local markets; extending time spent selling food products in the markets; providing home delivery where feasible; and understanding the social and physical barriers to product marketing. Finally, methods for determining appropriate pricing to ensure an adequate profit margin were reviewed as well as how to provide credit, quantity discounts, and special incentive offers to customers.

Results

The results of this technology-focused intervention include: 1) a high rate of adoption (77 percent) among women who participated in all three components of the intervention (adoption of the improved enclosed solar dryer as well as health and nutrition education and business training); 2) enhanced beta carotene content of foods dried in the improved dryers; and 3) significantly greater HKI scores among children whose mothers adopted the technology as compared to nonadopters (7.48 and 4.75, respectively) and in the intervention communities as compared to the control communities (post-intervention scores of 5.7 and 4.1, respectively).

This section starts with the findings related to the baseline assessment including HKI scores used to estimate prevalence of vitamin A deficiency, drying practices, and percentage of women earning income in the five intervention and three control communities. This is followed by findings on women's knowledge about the technology, dryer construction, and adoption rates, drying practices, and women's income and time allocation. Analysis of beta carotene content of dried vitamin A-rich foods and children's dietary intake of vitamin A are also reported. In conclusion, the authors explain the advocacy activities which were used to inform policymakers.

Baseline Assessment

Fifteen (of 29) communities in the Ilongero Division of Singida District were assessed for risk of vitamin A deficiency using the HKI food frequency methodology and its cutoff of a mean weighted total food frequency score of < 6 times/week for children 12-71 months. All 15 of the communities surveyed had scores that fell below this cutoff. The mean score was 3.2 in the five intervention communities, 3.6 in the three control communities and 3.5 in the remaining seven. These results suggest that this drought-prone region is at high risk of vitamin A deficiency and are consistent with findings from earlier studies (Mselle and Temalilwa 1993; Kavishe 1993).

Table 2 provides a summary of characteristics of the intervention and control households. It is important to note that the two sets of communities differed significantly at baseline in terms of women's literacy and education. More women in the intervention households were literate than in the control households, while more women in control households had some formal education than did those in the intervention communities. Although improvements in formal education and literacy may co-exist, one explanation for these differing results is that some communities may have benefited from development projects that promoted women's literacy but not their enrollment in the formal education system; whereas, others had the reverse. In general, technology adoption rates are positively associated with literacy and formal education, although the relative contribution of each is highly dependent on settings and circumstances.

It is also relevant to point out that while there were significantly more women in the control communities than in the intervention communities who dried vegetables at baseline, this shifted at post-intervention and the difference was no longer significant. While there was no significant difference between the percentage of women earning income in the intervention (85 percent) and control (82 percent) communities before the intervention, there was a significant difference ($p < 0.001$) at post-intervention, with significantly more women in the intervention communities (85 percent) engaged in income-generating activities than in control communities (68 percent). It is

not clear why the proportion in the control communities dropped during the intervention period. Another difference at baseline was that the intervention communities had a long history of vitamin A activities conducted by TFNC, including a project that promoted the production of fresh fruits and vegetables; whereas, the control communities in the current study had not had this same exposure.

Finally, results from the baseline survey are consistent with earlier studies indicating that malnutrition is a problem in this area. In the five intervention communities, the proportions of children between the ages of 12 and 71 months with low (< 2 SD) height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ) were 49 percent, 39 percent, and 9 percent, respectively (Kavishe 1993, Mselle and Temalilwa 1993). While there was a similar proportion of low HAZ (51 percent) and WHZ (10 percent) in control communities, there was a significantly greater ($p < 0.05$) proportion of children with low WAZ in the control communities (46 percent). In addition, a full 15 percent of women were undernourished with a body mass index less than 18.5. Similar proportions for women were observed in the three control communities. The high rates of stunting (HAZ) are symptomatic of the pervasive nature of poverty in the study area.

Women's Knowledge

One premise of the study was that if women believed that the improved solar dryers would be beneficial to themselves and to their families and were affordable, they would be motivated to adopt the improved technology and feed their children the value added food products. Post-intervention interviews found that a majority of women who adopted the improved enclosed solar drying technology correctly recalled a number of the advantages of the enclosed solar dryers as presented at the pre-intervention education sessions. These included more hygienic drying (89 percent), greater retention of the food's natural color (60 percent), and higher vitamin retention (60 percent). Although less than a third cited a reduction in product loss or deterioration or faster drying as advantages of the enclosed dryers, 69 percent reported that good dryer performance was a major reason they actually decided to adopt the new technology.

Adoption of the Improved Enclosed Solar Dryers

A summary of the adoption of the two types of improved enclosed solar dryers is shown in Figure 3. The total number of dryers constructed increased from 92 in July 1996 to 220 in July 1997. Over the same time period, the ratio of wooden to mud-brick dryers increased from 1.4:1

Table 2. General characteristics of the study and control populations (reported as percentage of total)

Characteristics	Pre-intervention			Post intervention		
	Intervention (n=250)	Control (n=150)	Statistical Significance	Intervention (n=239)	Control (n=126)	Statistical Significance
Literate women	46	36	$p<0.05$	–	–	–
Women with formal education	50	65	$p<0.001$	–	–	–
Married women	96	98	NS	90	91	NS
Women sun drying vegetables	88	94	$p<0.05$	99	98	NS
Women sun drying fruits	14	4	$p<0.005$	11	7	NS
Women earning income	85	82	NS	85	68	$P<0.001$

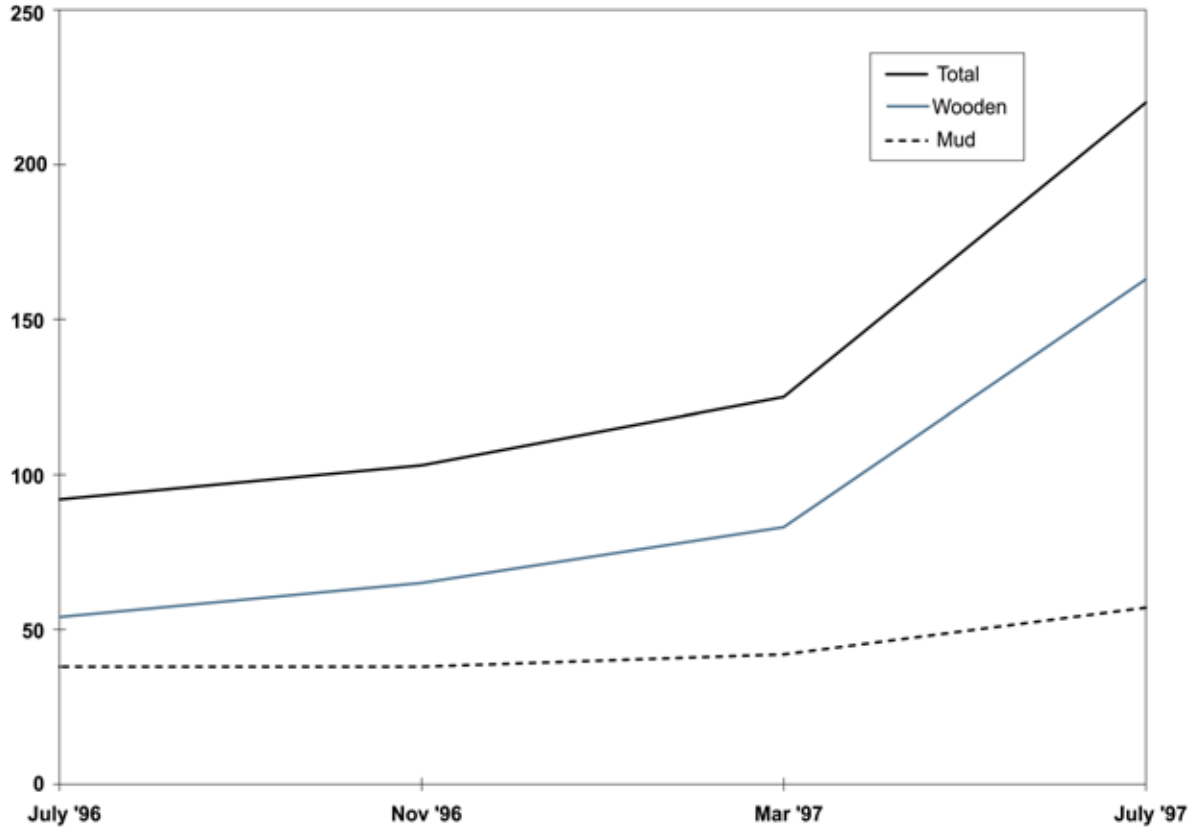
(54 versus 38) to almost 3:1 (163 to 57). Although the wooden dryers were more expensive to build, they were preferred due to their portability and durability, and because they were easier to maintain than mud-brick dryers were. Fifteen months after the introduction of the technology, a total of 210 households had built one or more dryers for their own use.

Women who attended the nutrition education and business training seminars were more likely to adopt the enclosed solar drying technology. Three hundred women or 12 percent of all women in the five intervention communities attended the nutrition education seminars. Of these, 82 percent (247 women) also attended the business training seminars. A total of 189 women of these 247 eventually adopted the dryer — representing a 77 percent adoption rate. Another 21 women who did not participate in the education and business management sessions adopted the technology. A total of 210 women adopted the smaller, home-sized solar dryers.

It should be noted, however, that only eight percent of all households (210 of 2500) in the five intervention communities adopted the dryers by the end of the study. Adoption of the technology appeared to relate to household socio-economic status. The mean household socio-economic status scores were similar in the intervention and control communities (5.0 and 4.5, respectively). However, the mean score was significantly higher among adopters than nonadopters (6.1 vs 4.5, $p < 0.01$). This suggests that households that adopted the technology may have had more financial resources at their disposal and were more likely to take a risk in using their own resources to construct the improved dryer models.

The role of the carpenters and artisans in terms of supporting construction and maintenance of the dryers was problematic. They charged clients

Figure 3. Adoption rate by dryer type



inflated prices for their services and construction of the dryers. The project team trained an additional artisan and carpenter per community to create a more competitive environment. While this minimized the problem, the incentive to maximize profits remained. It is not clear if this dynamic tension between the service provider and the client contributed to the slow rate of adoption. However, because household members assisted the paid workers during dryer construction, they should be able to build their own dryers in the future, reducing their dependence on others' labor.

Vegetable Drying Practices

If women constructed the dryers and had sufficient amounts of fresh fruits and vegetables for drying, the effects should be indicated by changes in the quantities of dried foods produced. To determine if such changes occurred, women were asked about what fresh fruits and vegetables they used and the quantities of each dried—at baseline and after the intervention. The data were collected during the dry season when consumption of dried food products was highest. Given that the data are self-reported and not verified, the following findings should be interpreted with some caution.

The majority of all women in the project area reported drying vegetables; however, the proportion of women who dried vegetables increased from 88 percent to 99 percent in the intervention communities. In the control communities, there was a smaller increase, from 94 percent before the intervention to 98 percent afterwards. Although the two groups of communities were different at baseline in terms of percent of women drying vegetables (88% in intervention and 94% in control) the difference disappeared at post-intervention (99% in intervention and 98% in control).

There were no significant differences either at baseline or at post-intervention in terms of the total amount of vegetables dried by the intervention or control groups. However, there was an increase in both groups by the end of the intervention period with the greatest gain occurring in the control communities. Intervention groups dried on average 26 liters per year; whereas, the control group reported a total production level of 24 liters. One year later, the intervention group reported drying approximately 32 liters as compared to 38 liters by the control group. It is unclear why the control communities increased their volumes to a larger extent than the intervention communities (14 vs 6 liters).

If the data are viewed only for adopters and nonadopters in the intervention communities, a different picture emerges. At this level, there was a large increase in the amount of vegetables that the adopters reported drying over a 12-month period – from an average of 26 liters (reported in July 1996) to 55 liters in July 1997. Nonadopters, on the other hand, produced only 33 liters in July 1997. Moreover, the adopters dried significantly ($p < 0.05$) larger quantities of a variety of vegetables cultivated in home gardens, including *matembele*, *kunde,* and *maimbe*, than the nonadopters.

Women's Income and Time Allocation

The proportion of women participating in income-generating activities involving dried vegetables was somewhat higher in the intervention (12 percent) than in the control communities (7 percent) before the intervention, but the proportions were similar (15 percent and 14 percent, respectively) thereafter (see table 3). The most important income-generating activity for the women in the intervention communities remained the sale of traditional alcoholic beverages brewed from maize or sorghum. In the intervention communities, the amount of income earned by women from selling green vegetables increased somewhat but this increase was not statistically significant, and income from selling green vegetables in the control communities seemed to increase even more.

Although no quantitative time allocation data were collected, observational and focus group data suggest that the improved dryers saved women and, in some cases, children time. Unlike

Table 3. Income-generating activities among women

	Intervention Communities		Control Communities	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Sources of income				
◆ Traditional brewing	43%	55%	37%	24%
◆ Crop production	37%	31%	42%	34%
Vegetable sales				
◆ Selling dried vegetables	12%	15%	7%	14%
◆ Bartering	10%	13%	7%	12%
Mean income from green vegetables[1]	119	163	96	266

[1] *In Tanzanian shillings*

open-air sun drying, foods in the improved enclosed dryers are protected from birds, animals, dust and other contaminants. It was, therefore, not necessary for women or children to stay close to the dryer to protect the foods while they were drying.

Beta Carotene Content of Dried Vegetables

The study compared the amount of beta carotene in vegetables blanched only but not dried with that of the same blanched varieties dried using the traditional open-air direct sun method and using the improved enclosed solar dryer (see table 4). In general, samples dried in the enclosed solar dryer retained more of their beta carotene content (between 56 percent and 90 percent) than those dried using the traditional open-air direct sun drying method (between 49 percent and 65 percent). The highest proportion of beta carotene was retained in the samples of *ngwiba*, cowpea leaves, and *mgagani*.

Although the beta carotene content of vegetables dried using the traditional method (direct sun drying) are rather high, they fall just outside the

Table 4. Beta carotene content[1] of green leafy vegetables (mcg/g) blanched then processed with different drying methods

Vegetable name	Not dried	Dried using traditional, direct sun method	Dried using enclosed solar dryer
	mcg/g	mcg/g (% retained)[2]	mcg/g (% retained)[2]
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 %)

[1] *Beta carotene content is the average of 3 tests using one sample from each of 3 communities.*

[2] *Percent of beta carotene retained based on amount of beta carotene in blanched undried sample.*

ranges for similar vegetables in other parts of the world (West and Poortvliet 1993).

Dietary Intake of Vitamin A-rich Foods

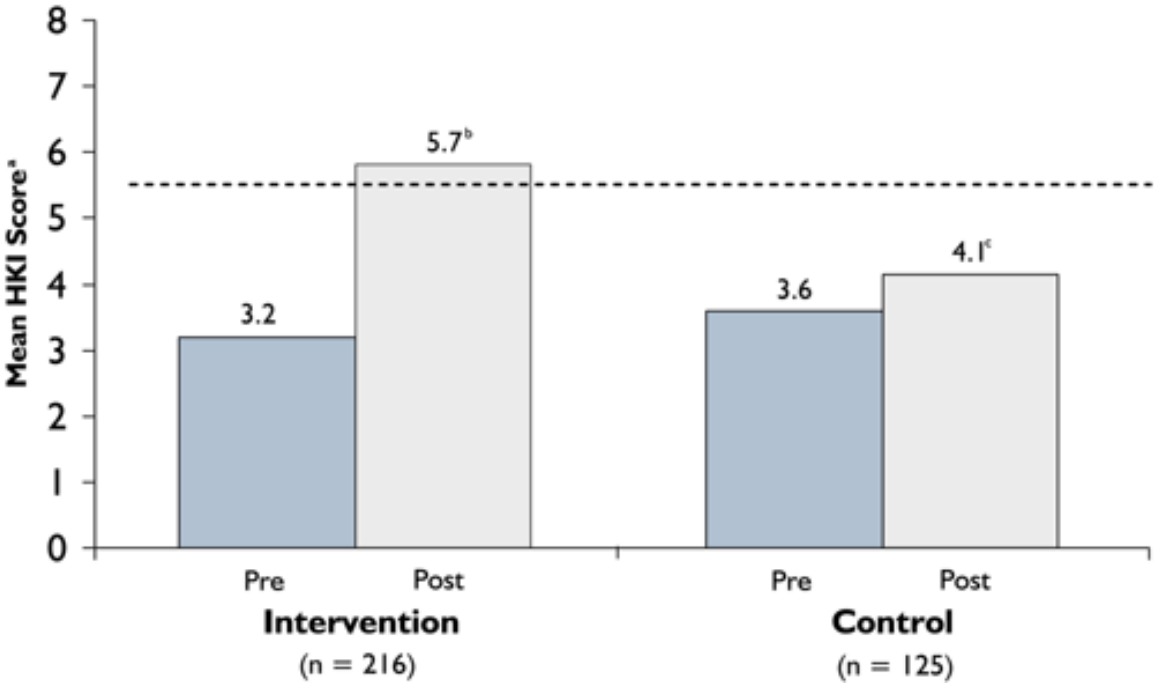
The HKI food frequency methodology was used to evaluate the effects of the intervention package over time between and within groups – intervention and control communities, and adopters and nonadopters living in intervention communities. Data were collected during the dry season, two years apart (October 1995 and October 1997).

As noted earlier, baseline data indicated that control and intervention communities differed in terms of proportion of women earning income, and proportions who were literate and who had some formal education. HKI food frequency scores in the two sets of communities at baseline, however, were similar—means of 3.2 for the intervention group and 3.6 for the control (see figure 4).

Following the intervention period, HKI food frequency scores increased significantly more among the intervention communities than among the control (post-intervention scores were means of 5.7 and 4.1, respectively, $p < 0.001$).

Food frequency scores in the intervention and control communities were further investigated regarding which foods contributed the most to the scores. There was no difference over time for either the intervention or control groups in plant food scores. Each had a mean score of 1.3 pre- and post-intervention with standard deviations of 0.5 and 0.4 for intervention and control groups respectively. Animal food scores, on the other hand, increased significantly in the intervention group, but remained about the same in the control group. Thus, 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, and the main contribution to the increase in

Figure 4. Pre- and post-intervention HKI food frequency scores of children in intervention and control communities



[a] *Calculated as days of animal food sources/week + [(days of plant food sources/week)/6]*

[b] *Significantly higher than pre-intervention score for intervention group ($p<0.001$)*

[c] *Significantly lower than post-intervention score for intervention group ($p<0.001$)*

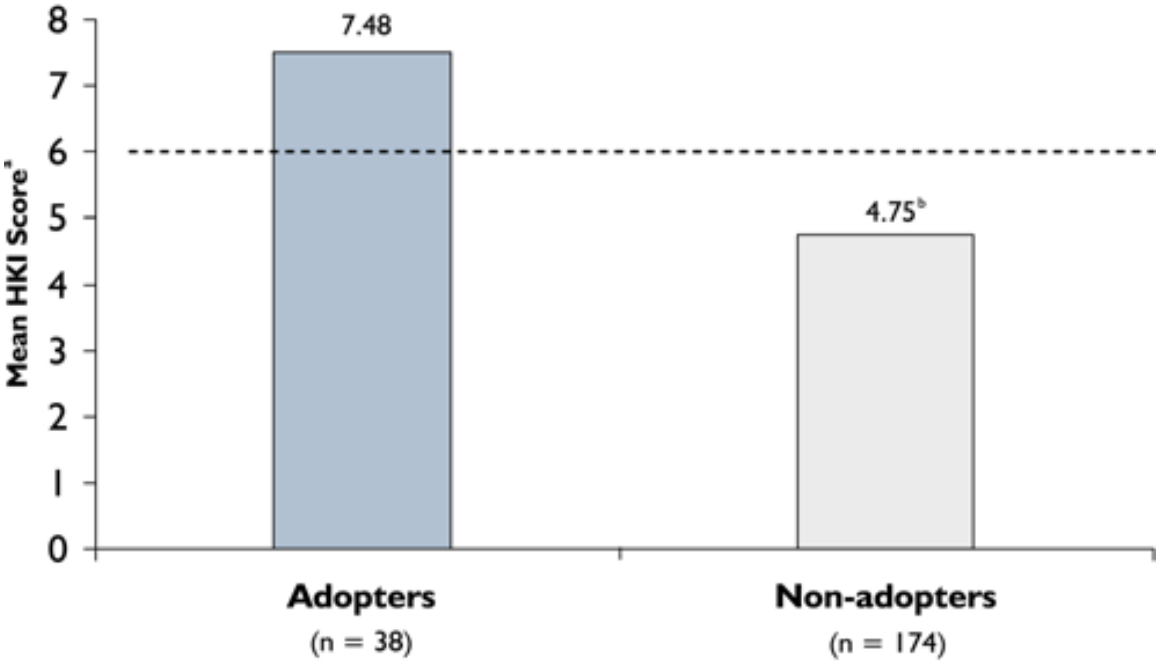
animal scores was from dried uneviscerated sardines (*dagaa*).

Adopter and nonadopter households were next compared within the intervention communities to explore the contribution of the improved solar dryer itself to explaining the improved HKI scores in the intervention group. HKI scores for young children in households that adopted the improved solar dryers were compared to those in households that did not adopt a dryer within the timeframe of the study. This permitted a comparison of the effect of the dryer itself because all households, whether they subsequently adopted or did not adopt, were exposed to the other elements of the intervention—community-level health and nutrition education, and business management training.

At post-intervention, young children from households that adopted the improved solar dryers had significantly higher mean consumption frequency of vitamin A-rich foods (HKI score) than children from nonadopter households (7.48 and 4.75, respectively) (see figure 5). There are two possible interpretations of this result. The dryers themselves might have enabled women to increase the amount of vitamin A-rich foods available to their families and which they fed to their young children. Alternatively, families who were able to respond the most quickly and adopt the improved dryers may also have more resources available in general, and may have responded more quickly to applying lessons from the health and nutrition education.

The overall contribution of the improved solar dryers to explaining the increase in HKI scores of the intervention group was minimal, however, because the number of adopters within the study timeframe was relatively small (210 of 2500 households, 8 percent). This suggests that the nutrition education component of the intervention may have had a larger effect on the main outcome of HKI scores than did the improved solar dryer component. The nutrition education most likely increased awareness that led mothers and families to feed more animal foods to the young children.

Figure 5. Post-intervention HKI food frequency scores of children in adopter and non-adopter households



[a] Calculated as days of animal food sources/week + [(days of plant food sources/week)/6]

[b] Significantly lower than adopters ($p<0.001$)

Advocacy Activities

The improved technology was a means to improve the nutritional value of seasonally available vitamin A-rich foods. Adoption rates of those who received all three components suggests that the technology was acceptable and affordable.

With the intention of creating institutional support for the promotion of the improved enclosed dryers and their potential contributions to increasing the dietary intake of vitamin A,[9] the researchers developed an advocacy strategy aimed at Ministry of Agriculture staff. During a one-day workshop held in February 1997, the major project findings were presented to a group of Regional and District level agriculture officers responsible for developing the next year's work plan for agricultural extension agents. The following key messages were stressed:

- Solar dryers are affordable;
- Solar dryers are in demand;
- Enclosed solar drying technology is an appropriate method for ensuring the year round availability of fruits and vegetables;
- Enclosed dryers produce more hygienic food products, decrease losses due to wind, birds, and insects and reduce women's workloads; and
- Solar dried foods retain more provitamin A-carotenoids than foods dried using traditional technologies.

As a result of the workshop, a training module on the use of the modified enclosed solar drying technology was incorporated into the Ministry of Agriculture's regional work plan. Lessons from the study also were shared with women from the Mungaa division in the Singida District who visited the project area in 1996. Consequently, construction and use of the enclosed solar dryers began in that division. In addition, TFNC received requests from other regions in the country (Kilimanjaro, Dar es Salaam, Coast, and Shinyanga) to provide technical assistance in introducing the enclosed solar drying technology to those areas and diffusion of the technology increased rapidly.

Finally, to ensure the consistent construction and use of the dryer, TFNC prepared a manual that summarized the experience and major findings of the Singida project as a guide for potential new users. The book, *Ukaushaji bora wa Mboga na Matunda,* was published in Swahili and a workshop was conducted with agricultural, community development, and health field workers to introduce them to the book. Copies were distributed to these field workers for their use in guiding communities' efforts to combat vitamin A deficiency in the drought prone regions of Tanzania.

[9] While dietary intake results did not show that children who lived in the intervention communities were eating more vitamin A-rich plant food sources, there was a potential to increase their consumption through additional education and training.

Discussion

The purpose of this study was to investigate whether community members, particularly women, would adopt improved solar dryers, and whether nutrition education combined with business management training and the use of improved solar dryers would ensure a year-round supply of vitamin A-rich foods, and lead to the improvement of the vitamin A intake among their children less than five years old. Nutrition education was expected to provide information on the health consequences of vitamin A deficiency needed to motivate and inform women about how to feed their children appropriate foods and stimulate positive caring practices. Access to a technology such as the improved solar dryer was expected to increase the quantity of foods that could be dried, and the concentration of vitamin A in the dried foods. Business education was expected to teach women that they could earn income if they dried surplus food and sold it, and then be able to buy health-promoting goods and services that would not otherwise be available to them.

Findings from the study suggest that women chose to adopt the new dryers, with the support of their families and community leaders. The adoption rate was slow but steady, and it was highest for those who had been exposed to the full intervention package. The dryer was used predominantly for dark green leafy vegetables, and leaves dried in the improved enclosed solar dryers had considerably higher concentrations of beta carotene than did those dried the traditional way in the open air.

Business management training seemed to have little immediate effect on women's income within the study's timeframe. Women did not dry leaves beyond their families' consumption needs, did not have a surplus to sell, and, therefore, did not earn income during the intervention period.

HKI scores of consumption frequency of foods rich in vitamin A by young children increased significantly during the study period in the group exposed to the set of interventions, largely due to a significant increase in the animal score, primarily from dried sardines. This main result is likely due to the nutrition education component of the intervention, not the introduction of the improved solar dryers because only a small proportion of the intervention group had yet adopted one, and not the business management training because only a few women applied the principles and actually increased their income during the study. Although the expected contributions of the dryer and the business management training were not as great as expected, each may have long-term potential for the further improvement of vitamin A status in these communities if continued efforts are made to support increased production and sales of dried food products using the improved enclosed solar dryers.

The Large Effect of Nutrition Education

The large increase in the frequency of animal sources rich in vitamin A that was attributable primarily to the health and nutrition education component of the intervention was a surprise. The education component was designed only as a two-day session, one day during which the entire community was invited and the second for women only. Extension workers and village executive officers involved in the study may have reinforced the nutrition education messages, but their attention was principally on construction and use of the improved solar dryers.

A possible explanation for the large size of the effect despite minimal nutrition education in this study is that the nutrition education provided reinforced nutrition education messages included in earlier TFNC activities. The intervention communities in this study had been exposed to

numerous TFNC activities promoting vitamin A, whereas the control communities had not. The horticulture project several years before had given them greater access to fresh fruits and vegetables for drying and project participants probably became more aware of the benefits of vitamin A-rich foods to their health, especially the health of their youngest children. The significant increase in HKI scores observed in this study, then, can be attributed to the short nutrition education session and its effect of building on the earlier TFNC projects in the intervention communities.

Benefits of the Solar Dryers and Potential Effects on Vitamin A Status

The dryers were well liked within the intervention communities. The adoption rate was slow because participants needed to save funds to purchase the materials to construct one for themselves, but it was steady over the course of the study (see figure 3 on page 18). Adoption was associated with increased socioeconomic status, a consistently reported pattern (Johnson-Welch 1999; Rogers 1983; Rogers 1969). Early adopters seemed to have a financial cushion that enabled them to take a risk by trying a new technology. Once the costs and benefits are demonstrated, others may be more willing to invest their scarce resources. Adoption of dryers is expected to continue beyond this study.

Women who adopted were pleased with the benefits of the dryers. They liked the light weight of the wooden dryers and, therefore, their portability. There were two models to choose from – the one made from wood was light weight but somewhat expensive, while the mudbrick one was heavier but considerably less expensive. To the authors' surprise, most women did not choose the lower cost mud-brick dryers, but instead chose the wooden ones, so they could easily move them outside during the days they were drying food and inside their houses overnight or when they were not in use. One of the main benefits perceived by the women was that, compared to traditional open air drying, less of their time was required for every batch of food dried. Because the dryers were enclosed, women did not have to spend time keeping animals away from the drying foods, as in the open air drying. Also, the overall time required to dry a batch of foods was shorter because the temperature inside the enclosed dryer was higher when it was standing in the sun compared to open air drying, thus creating an opportunity to produce more.

From the outset, researchers believed that there were three possible ways the improved solar dryers might contribute to improved vitamin A status in families, especially the young children. First, it was expected that the improved solar dryers would allow women to dry more dark green leafy vegetables and for family members in turn to consume more during the year. While women dried increased volumes, the HKI food frequency scores indicated that young children were not fed vegetables more frequently. Given that children were already fed leafy vegetables fairly frequently, this finding may indicate that mothers perceive that young children are already being fed enough of them. If this is the case, increased frequency of leafy vegetable consumption in this population is not a major means for improving vitamin A status, at least among young children, unless action is taken to reduce this presumed constraint.

Second, the improved solar dryers were expected to increase the concentration of beta carotene in the dried leaves compared to traditional open air drying. This expectation was confirmed in the study by the analysis (using high performance liquid chromatography techniques) of a variety of dried leaves. Beta carotene intake would be higher per serving of vegetables consumed and, assuming consumption remained constant, vitamin A status might be expected to improve. A recent study cast some doubt about the bioavailability of beta carotene from green leafy vegetables and its conversion to vitamin A, and, therefore, whether they could improve vitamin A status (de Pee 1995), although another study

which investigated a variety of green and yellow vegetables showed improvement in vitamin A status (Tang et al. 1999). To resolve the question of to what extent increases in beta carotene from dark green leafy vegetables can contribute to improvements in vitamin A status, future studies like the one reported here should assess vitamin A status (using biochemical indicators) of study participants.

Third, the pathway of improving vitamin A status through increasing women's income (as shown in figure 1) may be viable but would require more intensive efforts than the short business management training that was offered as a component of the intervention in this study. As recommended in the training, women did dry a greater volume of dark green leafy vegetables by the end of the intervention period than before. It was not clear, however, whether family members other than the children under five increased their consumption, or whether the surplus was used in another way. The proportion of women in the intervention communities who reported selling dried vegetables did not increase appreciably, but the amount of income earned from the sale of vegetables tended to increase slightly. This suggests that the pathway of improving vitamin A status through increasing women's income may have some potential for the future. Since such a small proportion of women reported earning income (indeed women do not have a major presence as vendors in the marketplaces), more preliminary investigation would be needed to develop a feasible and effective plan for promoting women's income generation using the improved enclosed solar dryers.

While not a part of the study, solar drying could be explored as a way to increase the year-round consumption of foods rich in vitamin A other than dark green leafy vegetables. Because of the current limitations of food variety in this drought-prone region, this would be worth pursuing given the risk of vitamin A deficiency in these communities.

Recommendations

The following recommendations are based on the findings of this intervention research study and suggest actions that can support efforts to find sustainable, acceptable, and affordable means to eliminate vitamin A deficiency in rural areas similar to those of the study communities.

■ **Explore the full potential of the intervention package to reduce vitamin A deficiency.** Although this technology package had three components — improved dryers, health and nutrition education, and business management training—findings suggest that the greatest effect on vitamin A dietary intake was a result of the education component. However, because the dryers did enhance the beta carotene retention in the processed dried foods and because women who participated in all three components adopted the dryers at a remarkably high rate, attention should be given to testing the full model by: (a) determining if promotional efforts can increase children's consumption of food products processed using the improve enclosed dryers; (b) determining if additional business management training and promotion of production of dried food products using the improved dryers can lead to increased income for women; and (c) measuring the effects of these changes on children's vitamin A deficiency.

■ **Continue to promote production of fresh fruits and vegetables.** Results suggest that the dryers enhanced the beta carotene content of the dried food products; however, this effect is wholly dependent on dryer owners having access to sufficient supplies of fresh produce to process in their dryers. The Ministry of Agriculture and other relevant institutions should continue to promote the production of fruits and vegetables to ensure continued use of the dryers as a potential mechanism for reducing vitamin A deficiency in this drought-prone area. Further research may need to explore ways to reduce constraints to production of these foods, including low-water use technologies.

■ **Increase demand for the dried food products.** Even if a particular household does not have a solar dryer, as long as there is a supply of these processed foods in the market at affordable prices, such household can benefit from the technology as well by purchasing dried foods. Thus, efforts should be invested in creating a demand for the dried food products. A market survey would suggest the marketability of the dried food products, including a greater variety of foods that are dried, if possible. A social marketing campaign could be implemented using data on taste, color, and other preferences, and women vendors could receive assistance, e.g., business management training or credit, in developing their own marketing strategies to establish viable business ventures based on these food products.

■ **Undertake a longitudinal study to determine if consumption of the plant food sources of vitamin A increases over time.** The findings indicated that children's intake of animal sources of vitamin A increased over the course of the study. This was an encouraging result, and deserves to be monitored longitudinally 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 beta carotene may have lower bio-availability and conversion to vitamin A than previously thought, future studies should confirm that vitamin A status (serum vitamin A levels) among young children improves following these food-based interventions.

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