ICRW/OMNI
Research Program

Research Report Series

3

The Effects of Women Farmers' Adoption of Orange-Fleshed Sweet Potatoes:

Raising Vitamin A Intake in Kenya

Vital Hagenimana
International Potato Center (CIP), Nairobi

Mary Anyango Oyunga
Kenya Agricultural Research Institute(KARI), National Potato Research Center, Limuru

Jan Low, *Universidade Eduardo Mondland, Mozambique (formerly with CIP)*
S.M. Njoroge, *CARE-Kenya, Homa Bay*
Simon T. Gichuki, *International Potato Center (CIP), Nairobi*
Jackson Kabira, *Kenya Agricultural Research Institute, National Potato Research Center, Limuru*

June 1999

International Center for Research on Women

ICRW

All photos by Kathleen Kurz/ICRW, except for front cover by J. Isaac.

The Effects of Women Farmers' Adoption of Orange-Fleshed Sweet Potatoes:

Raising Vitamin A Intake in Kenya

Contents

Acknowledgments

The authors would like to acknowledge the support for this project provided by the Kenyan Ministries of Agriculture and Health and members of the South Nyanza community. The District Agriculture Officer of Homa Bay kindly provided transport as needed, with particular help by the extension staff in Ndhiwa (Francis Oyuer, Patrick Odera, and Samuel Amara) and in Rongo (Shirley Tana and Cecilia Ombogo). The assistance of Fred Gweyo and Tobias Athiambo from CARE is also recognized, as well as the work of Paul Tana from KARI-Kisii on the advanced yield trials.

Special thanks goes to the International Potato Center (CIP) and KARI Headquarters for providing financial backstopping when the project was getting underway. The support of Charlotte Johnson-Welch and Kathleen Kurz of the International Center for Research on Women (ICRW) was much appreciated. Peter Ewell, Ted Carey, and Kathleen Kurz provided useful comments on report drafts.

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 could 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 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, sub-clinical 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 (ACC/SCN 1997), with widely divergent regional differences in rates. 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 Office of Health and Nutrition, United States Agency for International Development (USAID).

The studies were conducted in Ethiopia, Kenya, Tanzania, Peru, and Thailand. In **Ethiopia**, the goal was to improve vitamin A status among women and young children. Building on women's involvement in a dairy goat project, nutrition specialists worked with women's groups and elementary school teachers and students to improve food preparation and feeding practices and the production of vitamin A-rich foods. Menus were developed that used locally produced vitamin A-rich foods and the use of cooking oils to enhance absorption of vitamin A was promoted. Women, students and teachers received seeds and were trained in techniques to expand home and school gardens. Further, health and nutrition education lessons raised community members' and school personnel's awareness of the links between food consumption and health.

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.

In **Tanzania**, the focus was on the adoption of new home-based solar food dryers to increase year-round availability of vitamin A-rich foods. The dryers were adaptations of earlier models and were designed to be more cost effective and accessible. Community members provided all the materials for constructing their household dryers. The research project trained local artisans to construct and maintain the dryers, and provided a short-term incentive to artisans to conduct home visits. Nutrition and health education and business training for marketing surplus production of solar dried vitamin A-rich foods and food products complemented this technology intervention.

In **Thailand,** the 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 who were community leaders 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 cost of implementing some of the community-based actions, including food production, local preparation and sale of iodized salt, and health and nutrition education.

This report summarizes the findings from the intervention research project implemented in **Kenya,** where new varieties of sweet potatoes rich in beta carotene were introduced to women farmers. The Kenya Agriculture Research Institute provided planting materials and agricultural extension agents trained women in methods of growing and harvesting sweet potatoes, 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 varieties. The intention was to create supply and demand for the new food products both in the household and for market sales.

Background

Sub-clinical vitamin A deficiency is prevalent throughout Kenya, with extremely low serum retinol levels found primarily in the densely populated western region of the country (GOK & UNICEF 1995). The 1994-1996 Kenyan National Development Plan calls 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 (GOK 1994). Although targeting reduces costs and increases the efficiency of treatment for vitamin A deficiency, such programs are dependent on reliable supplies of capsules and a functional distribution system. Further, they are based on the presumption that those people most at risk will come in contact with health care providers in a timely manner. Another means for addressing vitamin A deficiencies is through the promotion of food-based, agricultural interventions. These are particularly effective in reducing sub-clinical vitamin A deficiencies and complement supplementation programs. One promising intervention involves the introduction and promotion of new varieties of sweet potatoes that are rich in beta carotene.

Sweet potatoes were of interest in this study for several reasons. First, 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 low in beta carotene. Consequently, 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 (Gakonyo 1993).

Second, orange-fleshed sweet potatoes have been identified as the least expensive, year-round source of dietary vitamin A (Low et al. 1997). While mangoes are the cheapest source, they are widely available only four months of the year. Cod liver oil is the second cheapest source per retinol equivalent, but 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. Other locally available sources of vitamin A include dark green leafy vegetables and papaya, which were also promoted throughout the trial intervention. Other vitamin A food sources not promoted in this study were carrots, which are not widely available in the study area and need more water for production than is feasible, and pumpkins, which have limited availability.

Third, sweet potatoes have the additional advantage of being considered a woman's crop. The goal of improving vitamin A status through the 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 (Sachs 1996). In light of the fact that women are usually responsible for ensuring a sufficient food supply for their families, they tend to keep most of their sweet potato harvest for home consumption. Even though women may sell some of their crop to acquire much needed cash, such sales tend to be small and the income earned remains under the control of the female producers (Quisumbing et al. 1998).

While women may have some control over production of certain food crops, men tend to make most major household decisions and to exercise control over their family's land, other productive resources, and expenditures. Consequently, they wield significant influence, even over women's crops and their promotion. Very few female-headed households existed in the study region of this project, with the result that men's decision-making roles were paramount. One man in Ndhiwa/Nyarongi who planted a large crop of sweet potatoes explained that if men find that the product has potential as a cash crop, they will allocate a portion of their own land to growing it and take control of production, market sales, and income generated.[1] Thus, sustaining an intervention that generates income for women requires careful attention.

The introduction of sweet potatoes described in this paper built on three stages of earlier research projects by KARI and CIP that identified varieties of orange- and yellow-fleshed potatoes acceptable to consumers and suitable for cultivation in the region (Low et al. 1996). During the earliest stage of research, preliminary trials were conducted at a field station in order to test the characteristics of more than 40 varieties of germ plasm in one type of soil. During the second stage of trials, ten additional types were grown more widely and their progress monitored. Finally, in the advanced yield trials, ten varieties of the potatoes were tested in a variety of agro-ecological zones under experimental conditions. Taste tests revealed that acceptability was correlated with a high level of dry matter content (greater than 27 percent) and with the orange color. The five varieties that were approved by producers and consumers and that performed well in the agro-ecological zones of the study sites were then subjected to on-farm trials, the focus of the current study.

[1] In fact, one man in the study area planted a large sweet potato crop, harvested and sold the potatoes all at once, and was proud to announce that the sale was enough to pay for the school fees of all his children. While such actions are positive from the perspective of infusing markets with the new orange sweet potato, a major drawback is that women could have less a share of the market if men adopt the variety as "theirs."

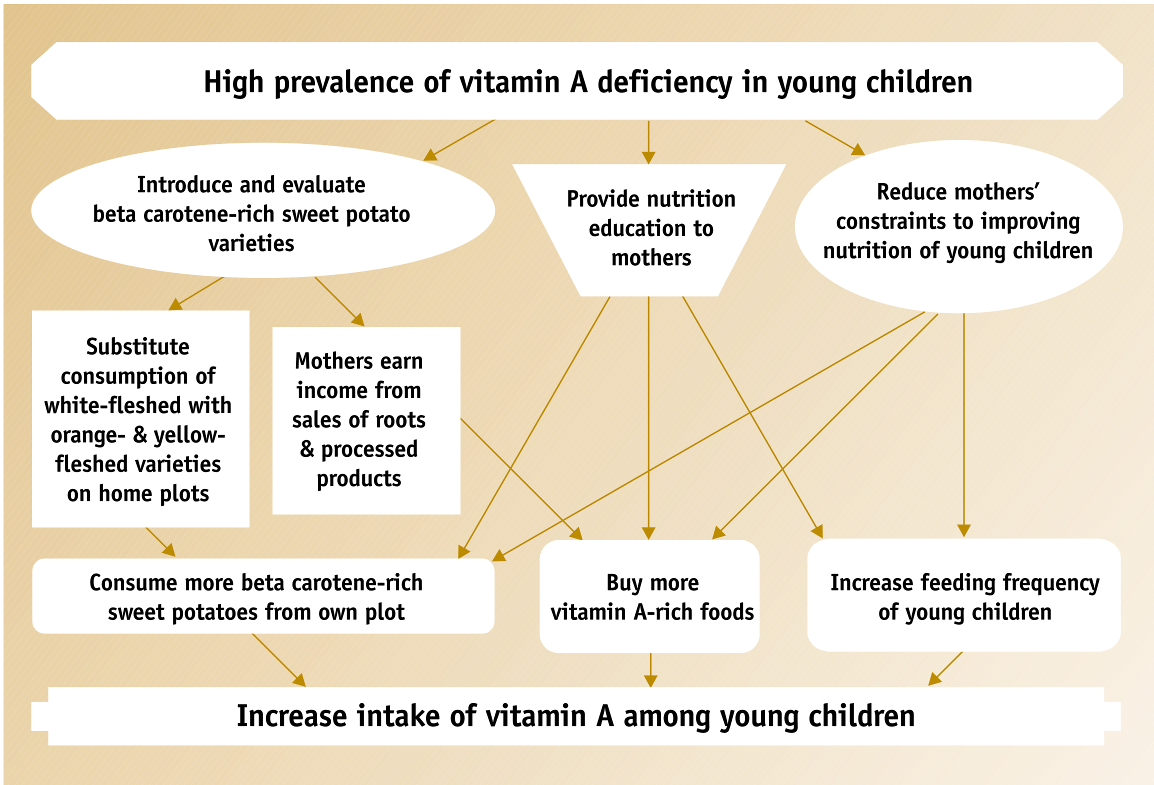
Conceptual Framework and Objectives

This report presents the findings of an intervention research study that examined the potential for new, beta carotene-rich (orange-fleshed) varieties of sweet potatoes to provide an inexpensive, year-round dietary source of vitamin A for communities at risk of micronutrient deficiency in western Kenya. The study was a collaborative effort involving the National Potato Research Center of the Kenya Agricultural Research Institute (KARI), the International Potato Center (CIP), and CARE-Kenya, Homa Bay.

The study was designed to increase the dietary intake of vitamin A among at-risk children through a set of complementary supports provided to women farmers. These included the introduction and promotion of orange-fleshed varieties of sweet potatoes, training in the processing and marketing of sweet potato-based food products, and the education of all community members on nutrition. A primary point of interest was whether vitamin A intake would increase with only the introduction of orange-fleshed sweet potatoes into the plots of selected women (i.e., the control group), or whether additional promotion through processing, marketing, and nutrition education were necessary (i.e., the intervention group).

Figure 1 illustrates the conceptual framework that guided the design and implementation of the study. It suggests that two ways to increase the vitamin A intake of young children are to introduce a new source of the micronutrient into the diet and to promote increased consumption of existing sources. The framework also indicates that the increased intake of vitamin A could occur through the purchase and consumption of vitamin

Figure 1. Conceptual Framework



A-rich foods with income earned from selling sweet potatoes, or through the consumption of processed foods made with the new varieties of sweet potatoes.

This study was not designed to test the relative benefits of consumption versus income pathways, but did (whenever possible) observe women's choices regarding the use of the sweet potatoes. Finally, the framework reflects one of the tenets of ICRW's five-country research program: Women will be better able to improve their young children's nutrition, as well as that of their families as a whole, if the constraints that they face in food production and consumption are reduced.

The specific objectives of the study were to:

- Identify orange-fleshed sweet potato varieties with high yield and high acceptability of appearance and taste that are appropriate for consumption by adults and young children.
- Educate women on the role of vitamin A in the diets of both children and adults.
- Develop and promote sweet potato-based infant weaning foods that retain significant amounts of the beta carotene content of the potatoes.
- Develop recipes and provide information about other sweet potato-based food products and evaluate the income generated from their sales.
- Increase the consumption of vitamin A-rich foods (particularly among children less than five years of age) and test whether this can be accomplished solely through agricultural extension services or whether nutritional promotion is also needed.

Study Design and Methods

Figure 2 illustrates the comparative nature of the study design and the content of each group intervention. As indicated, 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. Groups were chosen from two districts in western Kenya (Ndhiwa/Nyarongi and Rongo) according to a process described below in the Formative Research section. People in these areas were known to grow white-fleshed sweet potatoes and were thought to be at risk of vitamin A deficiency.

Criteria for group selection included organizational stability and cohesiveness; interest among members in growing new varieties of sweet potatoes; a high proportion of members with young children; and the willingness of many members to harvest and evaluate the varieties in conjunction with researchers. Further, it was decided that groups would not be excluded from selection merely because they had male members.

The study was designed to accommodate 20 women's groups, or ten from each district. To aid in the selection of groups, local leaders were asked to identify all women's groups in the districts. All ten groups in Ndhiwa/Nyarongi were selected to participate in the study, while ten out of 35 potential candidates were selected in Rongo. All 20 of the women's groups participated in on-farm trials and received visits from Ministry of Agriculture extension staff. As illustrated in Figure 2, half of the women's groups (five in Ndhiwa/Nyarongi and five in Rongo) were selected to receive promotional services from a project-hired fieldworker, i.e., nutrition education, training in sweet potato processing methods, and additional technical assistance. Each of the intervention groups was matched with a control group in the same district based on a pre-intervention frequency score of vitamin A-rich foods consumed in the previous week and on distance traveled to the local market.

Participatory rural appraisal methods were used to investigate control over vitamin A-rich food sources and inputs used for sweet potato production;

Figure 2. Study intervention and control groups

Intervention Group	Control Group
Five women's groups in each of two districts, Ndhiwa/Nyarongi and Rongo	Five women's groups in each of two districts, Ndhiwa/Nyarongi and Rongo
On-farm trials plus agricultural assistance	**On-farm trials plus agricultural assistance**
Promotion of orange-fleshed sweet potatoes through: ■ nutrition education ■ lessons on food processing ■ support from an agricultural extension worker and a project-hired fieldworker	[No additional promotion]

consumption of vitamin A-rich foods among study households; the extent to which women might sell or keep the sweet potatoes for household consumption; and men's enthusiasm for their own adoption of the new varieties. 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 any profits. The study compared women's perceptions of their control over these aspects of production, consumption, and sales to that of male elders, usually the husband's father; male adults, usually the husband; female elders, usually the husband's mother; and male and female children.

In addition to testing the most promising varieties of orange-fleshed sweet potatoes, the project selected a number of other varieties that were grown in plots supervised by researchers as part of advanced yield trials. These varieties were evaluated for yield and pest resistance and rated by consumers for their taste and appearance.

Total carotenoid, beta carotene, and dry matter content were measured in the fresh roots of the sweet potato varieties grown in both on-farm and advanced yield trials. Total carotenoid and beta carotene content were measured using column chromatography and spectrophotometric methods, as described by Imungi and Potter (1973). Dry matter was determined by oven-drying samples of freshly chopped roots, as described by Hagenimana et al. (1994). Similar analyses were conducted on selected processed food products to determine their beta carotene content.

Finally, the Helen Keller International (HKI) food frequency method[2] was used to assess consumption of vitamin A-rich foods among children under five years of age in the study areas. Although some methodological issues remain, e.g., breast milk is not factored into the score, the HKI method has been used extensively in the field and validated against serum retinol as an indicator of risk (Persson et al. 1998). The method also gives greater weight in the food frequency score to animal sources than plant sources. Furthermore, children under five are considered to be at greatest risk of the outcomes of vitamin A deficiency (such as blindness) and are, therefore, the most sensitive group in which to detect the problem within a family.

The HKI food frequency method was used in two ways in the current study. First, it was initially applied to assess whether vitamin A deficiency was an important public health problem in Ndhiwa/Nyarongi. Second, the HKI method was used to assess changes in food intake patterns by comparing baseline and post-intervention scores among the children of women in the 20 study groups.[3] ANOVA analysis was conducted using SPSS statistical software in order to compare HKI scores between the intervention and control groups in each community before and after the trial intervention.

[2] This method—developed by Helen Keller International in 1993—yields scores that reflect the number of days per week that children under five years of age were reported to have consumed animal and plant foods rich in vitamin A. According to HKI guidelines, communities with an animal source index of < 4 days/week or a mean weighted total food frequency index of < 6 days/week are considered at risk of vitamin A deficiency.

[3] Because this method is not appropriate for measuring vitamin A status, this study speaks only to risk of vitamin A deficiency and dietary intake.

Trial Intervention Phases

The study was conducted in three phases. First, in September 1995-April 1996, data were collected to inform the selection of the sample communities, the design of the intervention trial, and the baseline assessment of vitamin A intake among the children of women in the study groups. The second phase, from April 1996-June 1997, was a one-year intervention trial that included widespread distribution of sweet potato vines and related activities among half of the participating groups in order to promote consumption and sales. Finally, post-intervention data were collected in July 1997 to assess the effects of the trial intervention on frequency of vitamin A intake. At the same time, activities were undertaken to increase the awareness of Ministry of Agriculture staff about vitamin A deficiency and the role that promotion of the new orange-fleshed sweet potatoes could play in reducing this nutritional problem.

Formative Research, the Prevalence Survey, and Baseline Assessment

Three places in the Nyanza Province of western Kenya were considered possible intervention sites because they represent distinct agro-ecological zones suitable for sweet potato cultivation. A formative evaluation of these sites was conducted in September 1995 using the HKI methodology. Market surveys, key informant interviews, and group discussions about the feeding practices of young children and food availability were also conducted prior to the food frequency assessment.

Based on this formative research, Ndhiwa/Nyarongi and Rongo were chosen as the intervention sites. Criteria for this selection included climate, which is suitable for growing at least two crops of sweet potatoes each year, and the likelihood of vitamin A deficiency.[4] Socioeconomic status and health indicators suggest that communities in Ndhiwa/Nyarongi are less well off than those in Rongo, an area that has better access to markets and services due to its crossroads location.

The Ndhiwa/Nyarongi area was selected for a community-level prevalence assessment of vitamin A deficiency conducted in October 1995. The HKI method was used to randomly select 50 households from each of the area's 15 communities to participate in the survey. The HKI food frequency questionnaire was modified according to local food availability and administered in the 750 households. Data on general household characteristics, socioeconomic status, and sweet potato production in households were also collected. In April 1996, a second application of the HKI method was used to collect baseline data from households of members of the involved women's groups.

Trial Intervention

The results from the formative research phase led to the design of an intervention strategy consisting of activities geared towards selected women's groups. As noted above, all 20 groups in both communities participated in on-farm trials, while half also received interventions that promoted the processing, preparation, and consumption of food products containing orange-fleshed sweet potatoes. The time frame for selected activities is illustrated in Table 1.

[4] In fact, HKI scores indicated that Rongo had a lower probability of vitamin A deficiency than Ndhiwa/Nyarongi; however, the comparison between a market community (Rongo) and a non-market community was deemed of sufficient interest to proceed with the study in Rongo as well as Ndhiwa/Nyarongi.

Table 1. Time frame for selected project activities (*italics indicate seasonal events*)

Activity	Time frame
Short rains – maize and beans planted	*October–November 1995*
HKI food frequency questionnaire administered in 15 communities during the time of the baseline prevalence survey in Nyarongi and Ndhiwa/Nyarongi	October 1995
Sweet potatoes planted (first round)	*November 1995*
Sweet potatoes planted (first rounds) as part of advanced yield and on-farm trials with all 20 women's groups in Ndhiwa/Nyarongi and Rongo	October – November 1995
Pre-intervention HKI food frequency questionnaire administered in all 20 women's groups in Ndhiwa/Nyarongi and Rongo	February – March 1996
Long rains – maize and beans planted	*March – June 1996*
Harvest and taste evaluation conducted on first round of crops in advanced yield and on-farm trials in Ndhiwa/Nyarongi and Rongo	March – May 1996
Women's groups randomly divided into 10 control and 10 intervention groups in Ndhiwa/Nyarongi and Rongo	April 1996
Sweet potatoes planted (second round)	*June 1996*
Laboratory analyses of fresh roots and processed food products	October 1996
On-farm trials continue; intervention activities implemented	May 1996 – June 1997
Very short rains	*November 1996*
Sweet potatoes planted (third round)	*November 1996*
Long rains (normal duration)	*March – June 1997*
Post-intervention HKI food frequency questionnaire administered in all 20 women's groups in Ndhiwa/Nyarongi and Rongo	July 1997[5]

Trials of new sweet potato varieties conducted by KARI and CIP in 1994 led to the identification of a number of orange- and yellow-fleshed potatoes suitable for cultivation in the study areas. The research team active in the on-farm trials selected five varieties that were most promising for distribution and planting by the women's groups. In addition, for comparison purposes, the women's groups selected one popular local variety to plant in Ndhiwa/Nyarongi and another to plant in Rongo (i.e., 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. Sweet potatoes from the on-farm plots were harvested in April and May 1996 and data 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

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

women and men could assess their appearance and taste. Project participants and the research team also assigned a general satisfaction rating to the varieties based on growing and handling performance. Agricultural extension agents visited the farmers at three points in time (planting, mid-season, and harvesting) to support the adoption of these varieties.

The intervention group received nutrition education and training in sweet potato processing methods. They also participated in rural rapid appraisal methods (led by CARE extension agents) to explore how the new sweet potato varieties could be used for both home consumption and market sales. The nutrition education component focused on messages related to the importance of vitamin A for disease prevention and good eyesight and to the identification of foods other than orange-fleshed sweet potatoes that contain vitamin A (e.g., egg yolks and dark green leafy vegetables). In addition, women were taught how to add the potatoes to existing infant weaning foods and how to prepare new weaning foods rich in vitamin A using locally available commodities.

The women's groups conducted recipe trials using the new varieties of sweet potatoes, for example in cakes, doughnuts, biscuits, bread, *chapatis*, chips (french fries), weaning mixtures, and crisps (potato chips), and evaluated them for appearance, taste, and ease of preparation.

One project fieldworker in Ndhiwa/Nyarongi and one in Rongo worked with the women's groups to explore other options for using the new potatoes. These included selling the potatoes in local or distant markets, establishing rapid multiplication plots for the new varieties, selling planting materials, using new technologies for storing fresh roots or dried chips, and improving agronomic practices. The fieldworkers, together with agricultural extension workers from the Ministry of Agriculture, initially worked with the study groups and then made home visits to individual members on a monthly basis. These visits provided a means for the farmers to identify technical difficulties in utilizing the new sweet potato varieties and to develop solutions to overcome such constraints.

Results

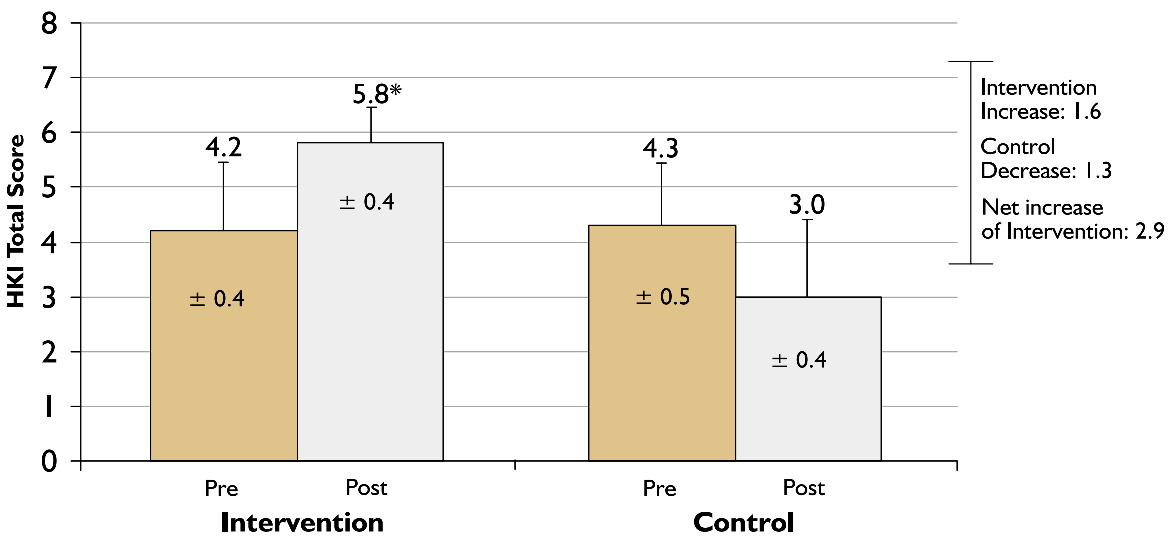
This section presents the results of applying the HKI food frequency method to estimate changes in the dietary intake of vitamin A food among children under five years old in the households of study participants. These findings are followed by results from the on-farm trials, findings on the nutrient content of the five new orange-fleshed sweet potato varieties tested in the on-farm trials, and a description of food products developed using the new varieties. In addition, study results related to women's control over resources and policy advocacy are presented.

HKI Food Frequency Scores

Results from the prevalence survey conducted in the Ndhiwa/Nyarongi division in October 1995 clearly indicate that vitamin A deficiency is a critical public health problem in this area of Kenya.[6] 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 animal sources of vitamin A was three days per week, which is also below the threshold of 4.0. No community exceeded the threshold for the weighted total food frequency scores and only one exceeded the threshold for animal food sources.

In order 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 20 women's groups. The ten groups in Ndhiwa/Nyarongi had a total of 154 children five years of age or under, while the ten in Rongo had 159. The results for the HKI total score in Ndhiwa/Nyarongi are shown in Figure 3. Baseline (pre-intervention) scores were similar for both the intervention and control groups. HKI scores in the intervention group increased significantly (+1.6 points) from pre- to post-intervention, while 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 percent increase over the pre-intervention level and was highly significant (ANOVA p = 0.0015 for the intervention period interaction term).

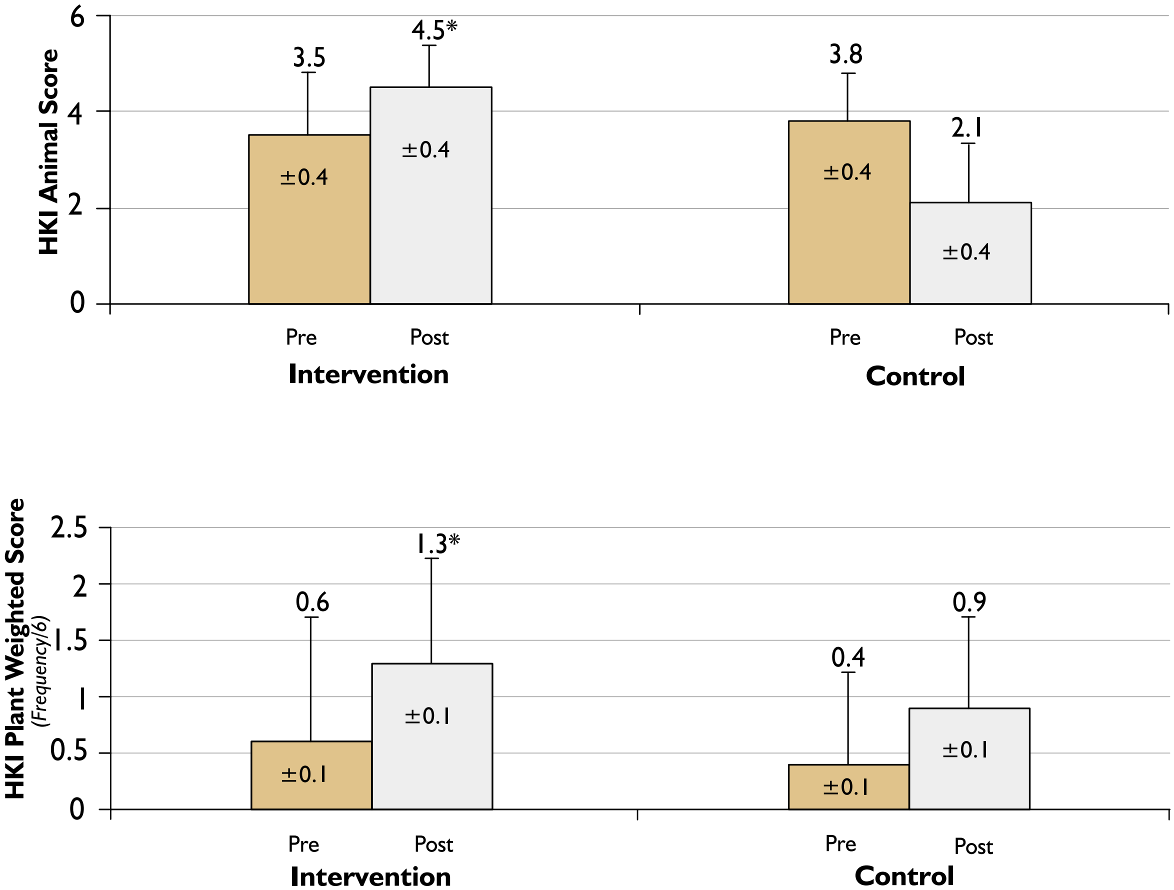
Figure 3. Frequency of consuming vitamin A-rich foods in Ndhiwa/Nyarongi (n = 154, children 0-5 years)



**The increase from pre- to post-intervention period was significantly greater in the intervention group than the change in the control group (ANOVA, p = 0.0015)*

[6] Detailed results from this phase of the study have been published elsewhere (Low et al. 1997) and only the HKI food frequency scores are reported here.

Figure 4. Animal and plant components of HKI scores (Ndhiwa/Nyarongi)



**The increase from pre- to post-intervention period was significantly greater in the intervention than the change in the control group (ANOVA p = 0.0015)*

The animal and plant food components of the HKI scores are shown in Figure 4. 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 post-intervention, while the control group score decreased (-1.7 points), resulting in a net highly significant increase of 2.7 points (ANOVA $p = 0.0015$ for the intervention period interaction term). In fact, the animal component contributed the major portion of change in the total HKI scores due to higher consumption of egg yolks and *ghee* (butter).

The plant component of the score also increased and was statistically significant (ANOVA $p = 0.01$ for the intervention and period main effects terms). The score pattern for plant foods differed from that of the animal food score, with both intervention and control groups showing higher scores in the post-intervention period. This increase in both the intervention and control groups was due in large part to higher consumption of orange-fleshed sweet potatoes, as well as mangoes and dark green leafy vegetables.

Results from Ndhiwa/Nyarongi indicate that activities carried out in the intervention group that went beyond the distribution and cultivation of orange-fleshed sweet potatoes (i.e., the activities pursued with the control group) were crucial to increasing HKI scores. Promotional activities included nutrition education, lessons on food processing, and more intensive support from an agricultural extension worker.

At the same time, the control group actually showed a decrease in its scores. It must be noted that there was a drought in the region the previous year, which affected both control and intervention groups, and could have accounted for the decrease in scores. However, the absence of a similar decrease in the intervention groups' scores suggests that the promotional activities may have contributed to their ability to cushion the effects of the drought.

Results from Rongo are shown in Figure 5. Increases in the HKI scores that occurred as a result of the intervention were not statistically significant. Scores in the pre- as well as the post-intervention period were all greater than the threshold of 6.0, which may suggest that promotional efforts are unlikely to increase consumption of vitamin A-rich foods in areas where such consumption is already adequate.

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. Yield ranged from 4.5 -18.8 tons per hectare (see Table 2). The highest overall yields in both project areas were obtained with the Simama, Pumpkin, and Japanese varieties, while the worst performance was observed with the local check varieties. Mean yields were higher in Rongo than in Ndhiwa/Nyarongi due to both higher rainfall during the rooting period and better management of the trials. Participating farmers also assigned a general satisfaction rating to the sweet potato varieties with regard to overall agronomic performance. On a scale of 1-5 (with 1 being very bad), ratings ranged from 1.6 for the local check variety in Ndhiwa/Nyarongi to 3.9 for the Simama potato grown in Rongo. The pattern of these ratings was similar to that observed for the overall yield.

In both Ndhiwa/Nyarongi and Rongo, the results of the taste tests and appearance evaluations of cooked sweet potatoes also indicated that the Simama, Pumpkin, Japanese, and Kakamega 4 varieties were acceptable to community members, as shown in Table 2. Because of its low dry matter content, Pumpkin was preferred for use in weaning foods, an exception to the adults' general preference for sweet potatoes with a high dry matter content. As expected, the local check varieties ranked high in terms of taste and

Figure 5. Frequency of consuming vitamin A-rich foods in Rongo (n = 159, children 0-5 years)

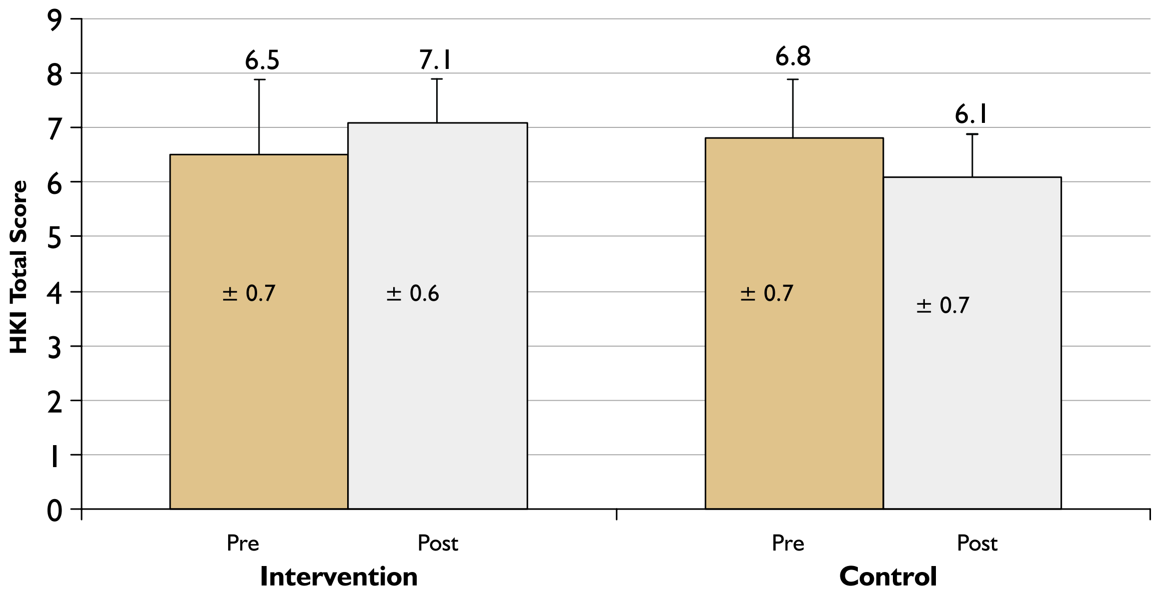


Table 2. Taste and appearance ratings[1] of cooked sweet potato roots grown in on-farm trials

	Ndhiwa/Nyarongi				Rongo			
Sweet potato variety	n[2]	Yield (T/ha)	Taste	Appearance	n[2]	Yield (T/ha)	Taste	Appearance
Simama	108	11.2	3.68	3.28	89	18.8	4.09	3.78
Pumpkin	109	9.3	3.21	3.45	89	12.8	3.80	3.59
Japanese	106	8.7	3.24	3.22	89	14.4	3.70	3.57
Kakamega 4	94	8.6	3.78	3.58	89	10.2	3.55	3.85
Maria Angola	108	7.7	2.98	3.17	89	9.7	3.52	2.47
Local check	79	4.5	3.78	3.51	89	6.0	3.90	3.56

[1] *Taste and appearance evaluation scale: 1 = very bad, 5 = very good*
[2] *Number of community participants*

appearance. In Ndhiwa/Nyarongi, the taste of Kakemega 4 and Simama were preferred to the Japanese and Pumpkin varieties, while in Rongo, Simama and Pumpkin were preferred to the Japanese and Kakemega 4 varieties. In both areas, the Maria Angola variety ranked last in terms of appearance and taste and was therefore eliminated from further cultivation and distribution efforts.

Beta Carotene, Total Carotenoid, and Dry Matter Content

As shown in Table 3 and in keeping with previous reports, beta carotene was the major carotenoid found in the sweet potato varieties grown in on-farm trials (Woolfe 1992). The beta carotene content was highest in Kakemega 4 and Japanese varieties and lowest in the Simama and local check variety from Ndihwa. The beta carotene

Table 3. Root color, dry matter, total carotenoid, and beta carotene content of sweet potato varieties

Sweet potato variety	Root color	Dry matter (%)	Total carotenoids[1]		Beta carotene content[2]		Retinol equivalents[3]	
			N/N[4]	Rongo	N/N	Rongo	N/N	Rongo
Kakamega 4	Orange	28.6	7.5	5.3	5.5	4.1	912	683
Japanese	Orange	25.3	4.3	4.7	3.9	3.8	645	635
Pumpkin[5]	Orange	19.6	2.4	-	1.3	-	217	-
Simama	Yellow	33.1	1.2	1.4	0.1	0.2	18	38
Maria Angola	Light yellow	27.0	3.9	3.8	-	0.9	-	108
Oduoko (local check)	White	34.6	0.2	1.5	0.1	n.d.[5]	13	n.d.[6]

[1] *mg total carotenoids/100 g fresh root*
[2] *mg beta carotene/100 g fresh root*
[3] *Based on a conversion factor of 0.006 mg beta carotene: 1 retinol equivalent*
[4] *Ndhiwa/Nyarongi*
[5] *Roots from Kabete, Nairobi*
[6] *Not determined*

content of several of these varieties exceeded 100 retinol equivalents per 100 grams of dry weight, signaling a good dietary source of pro-vitamin A. In addition, carotenoid content was directly related to color, with the highest level found in orange-fleshed roots, medium content found in cream colored roots, and the lowest content found in yellow, white, and purple varieties. These data (not shown) support the idea that color intensity may be used as an indication of pro-vitamin A value in sweet potatoes (Takahata et al. 1993).

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

Content analyses conducted on samples of 32 additional varieties of potatoes grown in the advanced yield trials in the two areas showed that beta carotene was the major carotenoid present. Fortunately, the dry matter content of many of these varieties exceeds the level of 25 percent generally associated with consumer acceptance. This suggests that a number of the varieties grown in the advanced yield trials could be promising candidates for cultivation given their agronomic performance and beta carotene and dry matter content.

Effect of boiling on total carotenoid content. As illustrated in Table 4, the effect of boiling roots was assessed using three regimes lasting 30, 45, and 60 minutes. Boiling for 30 minutes resulted in a reduction of total carotenoid content, which varied depending on the cultivar: 14 percent in the local check, 26 percent in Japanese, 34 percent in Simama, and 59 percent in Kakamega 4. However, this gradual reduction was not necessarily exacerbated by increasing cooking time from 30 to 60 minutes. This was especially the case with Japanese and Kakamega 4 varieties, which had the highest initial levels of carotenoid content. After one hour of boiling, Simama lost 57 percent of its initial total carotenoid content, while the local check lost only 29 percent.

Effect of the farming environment on carotenoid content. Total carotenoid content depended greatly on farming site and type of cultivar. For example, Japanese cultivars had a higher total carotenoid content in Kisii than elsewhere in the study areas. The difference in beta carotene content for cultivars grown in Kiboko, Kabete, and Kisii was not significant, except for the cultivar used as the local check, which had a very low value in Kisii (see Table 5). However, the high performance liquid chromatography (HPLC) profiles of each of the four cultivars used in this experiment were similar among the farming sites with regard to numbers and had identical main carotenoid peaks. Overall, the difference in total carotenoid content across farming sites was inconsequential

Table 4. Total carotenoid content of boiled sweet potato storage roots from four different cultivars

Cultivar	Total carotenoid content* *(mg/100g boiled root ± SD)*			
	Raw sweet potato	Roots boiled for 30 min.	Roots boiled for 45 min.	Roots boiled for 60 min.
Simama	0.9 ± 0.0	0.6 ± 0.1	0.6 ± 0.0	0.4 ± 0.1
Kakamega 4	3.1 ± 0.1	1.2 ± 0.1	1.7 ± 0.0	1.7 ± 0.3
Japanese	6.7 ± 0.0	5.0 ± 0.1	6.6 ± 0.1	6.6 ± 0.1
Local check	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0

**Values less than 0.05 mg/100 g fresh root are indicated as 0.0*

Table 5. Total carotenoid and beta carotene contents of four sweet potato cultivars in three different farming environments in Kenya, 1996.

Cultivars	Kabete (altitude: 1,800 m; temperature: 20.3±3°C; rainfall: 1,046 mm)		Kiboko (altitude: 975 m; temperature: 19.3±4°C; rainfall: 595 mm)		Kisii (altitude: 1,765 m; temperature: 19.2±4.9°C; rainfall: 1,952 mm)	
	Total carotenoid content*	Carotene content*	Total carotenoid content*	Carotene content*	Total carotenoid content*	Carotene content*
Japanese	5.5 ± 0.3	4.6 ± 1.4	5.5 ± 0.4	5.5 ± 0.4	7.7 ± 0.3	5.9 ± 0.4
Simama	0.4 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	0.1 ± 0.0	0.4 ± 0.0	0.1 ± 0.0
Local check	0.1 ± 0.0	< 0.1	0.1 ± 0.0	< 0.1	0.1 ± 0.1	< 0.1
Kakamega 4	2.3 ± 0.1	1.5 ± 0.1	2.6 ± 0.2	1.5 ± 0.1	2.7 ± 0.1	1.9 ± 0.2

** mg/100 g fresh root ± SD. Values less than 0.05 mg/100 g fresh root are indicated as 0.0.*

in terms of vitamin A value because beta carotene did not vary.

Sweet Potato-based Processed Food Products

Processed food products made from new sweet potato varieties were well accepted by food processors and consumers. The processing of modified food products did not require additional labor or production costs. In addition, a cost analysis indicated that substituting sweet potato for wheat flour in *mandazis* made the product more profitable for market vendors (i.e., a profit of 15 Kenyan shillings, rather than a loss of 47).

Substituting sweet potato for other ingredients dramatically increased the beta carotene content of processed food products. *Mandazis*, *chapatis*, and buns made in the traditional manner contained approximately 100 mg beta carotene equivalents per 100 grams of food product, whereas the beta carotene content of modified food products ranged from 800-3200 milligrams per 100 grams.

Control Over Resources

Results from this intervention study 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 for permission to access additional land. Men most often control stored wealth (e.g., livestock or machinery) and most women, especially in Ndhiwa/Nyarongi, do not control sufficient cash to hire ploughs 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 about doing so. In sum, the potential for increasing women's income generated through the cultivation of sweet potatoes exists but requires further exploration.

Policy Advocacy Activities

In order to increase the application of study findings by policy makers in Kenya, a set of activities were designed for staff at the Ministries of Agriculture and Health. These activities aimed to increase awareness among district- and division-level agriculture and health workers that vitamin A deficiency is a problem that can be alleviated through the production and consumption of sweet potatoes rich in beta carotene.

Heads of districts and divisional level staff from four sweet potato-growing districts in Nyanza Province participated in an advocacy workshop held in Homa Bay on July 28-29, 1997. Results from the intervention trial were presented. Workshop participants also visited one of the women's groups and heard reports from study participants about their success in growing, processing, and selling products made from the new sweet potato varieties.

One result of the workshop was the development of action plans by government staff. Strategies to popularize the new sweet potato varieties included field days, radio programs, workshops, staff training seminars, and tours to the intervention sites in Rongo and Ndhiwa/Nyarongi.

Discussion and Conclusions

The results of this study indicate that orange-fleshed sweet potatoes and sweet potato-based food products were not only acceptable to both producers and consumers in the target communities in terms of appearance, taste, and texture, but contributed to the alleviation of vitamin A deficiency. Several of the new sweet potato varieties grown in the on-farm trials performed well with respect to yield and pest resistance and also had a high beta carotene content. In addition, processed food products made by substituting sweet potato for other ingredients proved to be popular. 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, beta carotene-rich food source highly attainable.

The main nutrition 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/Nyarongi (an area that initially had low scores) was sizable after only one year of intervention activities. A net increase of 93 percent was attained in the scores, the improvement was statistically significant, and the final score in the intervention group almost reached the recommended threshold of 6.0 for identifying communities at risk of vitamin A deficiency.

This suggests that simply distributing beta carotene-rich varieties of sweet potatoes and providing minimal agricultural support for their production is not sufficient to increase HKI food frequency scores among children in the study area. Such support must be accompanied by activities, e.g., training in food processing or health and nutrition education, that promote their consumption by at-risk populations, including young children.

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. First, following the initial nutrition education and food processing lessons, the project's two fieldworkers made home visits to members of the women's groups on a monthly basis in order to establish an open rapport. The fieldworkers reviewed parts of the lessons as needed and answered questions, which at times involved the reconciliation of nutrition education with cultural beliefs or 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.

Second, the women participants responded well to the lessons on how to process orange-fleshed sweet potatoes for use in common foods. Initially, the research team thought that lessons would only be appropriate in Rongo, where markets are more available to women vendors. However, upon request, women in Ndhiwa/Nyarongi were also taught how to make the processed foods for home consumption. This suggests the utility of including processing techniques as part of the comprehensive adoption package, rather than targeting it only to those who may use the techniques to prepare foods for market sales.

A cost analysis in Rongo showed that when sugar and wheat flour were substituted by orange-fleshed sweet potatoes in two starchy snack foods, the products could be produced at a lower cost and sold for the same price at the market. Furthermore, the modified snack foods were well liked and sold quickly.

Numerous elements of this intervention suggest its potential sustainability. First, the widespread dissemination of vines to grow orange-fleshed sweet potato roots occurred quickly, even during the time that the study was being conducted.

Given the popularity of the vines, demand would likely grow in the future, particularly if local KARI offices continue to make planting materials available. Furthermore, 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.

Second, on-farm trial data showed that the new sweet potato varieties survive droughts well and have yields higher than the traditional white varieties, factors that are important for sustained cultivation. Third, the study aimed to strengthen women's control over some of the resources they need to feed their families and improve or sustain the nutritional status of household members, in particular young children. The sweet potato crop was chosen as a focus for intervention because women traditionally make most decisions about its planting and harvesting, whether it is consumed or sold in small quantities, and how to spend the money generated by its sale. 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. Thus, women controlled both the production and consumption aspects of this important food crop and were therefore able to meet their dual responsibilities in an efficient and effective manner. This in turn suggests the likelihood that the women participating in the study will continue to apply the lessons they learned through this project.

With regard to replication, the project's success in linking agricultural production and nutritional benefits was a result of the provision of extension services to the women farmers. The model used was based on the inclusion of specially hired extension workers in order to complement the services provided by the Ministry of Agriculture's extension agents. It is conceivable that the Ministry's extension agents, particularly those with a nutrition background, could be trained to address both production and consumption issues. However, a number of factors would need to be addressed in order for these agents --- who typically focus only on the production side --- to take on an expanded role, including farmer-to-agent ratios, training and supervision for quality control purposes, and incentives. If the Ministry of Agriculture extension agents are not best placed to play a role similar to that of the project-hired extension workers, then alternative "agents" must be identified. Addressing the means to provide direct human support to the farmers would contribute greatly to replicating this project's model for achieving nutritional improvements through an agriculture-focused intervention.

A final note relates to the contribution that sweet potatoes can make to improving the vitamin A intake of young children. Although the link between some beta carotene-rich vegetable sources, particularly dark green leafy vegetables, and improvements in vitamin A status has been questioned (de Pee et al. 1995), recent data from Indonesia suggest that consumption of beta carotene from red sweet potatoes, an alternative vegetable source, yielded measurable improvements in serum retinol levels (Jalal et al. 1998). These Indonesian varieties are similar to orange-fleshed ones introduced in the Kenya study. Interestingly, using HPLC, K'osambo et al. (1998) recently found that more than 80 percent of total carotenoids present in potato varieties used in the current study were beta carotene. Thus, it is likely that food-based strategies that promote the consumption of orange-fleshed sweet potatoes, such as the one described in this report, will prove to be an effective way to improve the vitamin A status of young children and their families around the world.

Recommendations

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

■ **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, for example at Alemaya University of Agriculture in Ethiopia. It is therefore important to expand efforts to promote production and consumption of appropriate varieties of food crops in parts of these regions that have similar levels of the deficiency.

■ **Strengthen women's ability to carry out dietary change in their households.** Since women are primarily responsible for their family's diet and for the care of children, it makes sense to consider ways to strengthen their ability to meet these responsibilities. In this study, the ability of women to meet the nutritional needs of their families was strengthened by identifying 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 could yield similar nutritional benefits for agriculture-based economies that have high rates of sub-clinical vitamin A deficiency.

■ **Train appropriate extension workers in basic health/nutrition messages.** While 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, it might be reasonable to provide agricultural extension workers with additional training in order to make the link between agricultural production and food consumption. However, taking on this task and implementing it in a consistent fashion may mean changing job descriptions and perhaps providing an incentive to encourage extension workers to take on new responsibilities (Henderson 1995; Sachs 1996).

■ **Involve others in the promotion of 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, can only be beneficial. Elementary school-aged students, particularly girls, should also be key target audiences. Given the influence that girls may have on their future families' health, it would be beneficial for them to learn basic health and nutrition principles and how to ensure food security on the household level.

References

Administrative Committee on Coordination/Subcommittee on Nutrition (ACC/SCN).
1997.
The Third Report on the World Nutrition Situtation. World Health Organization. Geneva, Switzerland.

de Pee, S, C.E. West, Muhilal, D. Karyadi, and J.G. Hautvast.
1995.
"Lack of improvement in vitamin A status with increased consumption of dark green leafy vegetables." *Lancet* 346: 75-81.

Gakonyo, N.
1993.
Processed Sweet Potato: Responding to Kenya's Urban Food Needs. (Working Paper.) Department of Agricultural Economics. Cornell University Press. Ithaca, New York.

Government of Kenya.
1994.
National Development Plan for the Period 1994 to 1996. Government Printer. Nairobi, Kenya.

Government of Kenya and UNICEF.
1995.
Vitamin A Deficiency in Kenya: A Report of the National Micronutrients Survey. Government Printer. Nairobi, Kenya.

Hagenimana, V., R.E. Simard, and L.P. Vezina.
1994.
"Amylolytic activity in germinating sweet potato (*Ipomoea batatas L.*) roots." *Journal of the American Society of Horticultural Science* 119 (2): 313-320.

Henderson, H.K.
1995.
Gender and Agricultural Development: Surveying the Field. University of Arizona Press. Tucson, AZ.

Helen Keller International.
1993.
How to use the HKI food frequency method to assess community risk of vitamin A deficiency. New York, NY.

Imungi, J.K. and N.N. Potter.
1973.
"Nutrient content of raw and cooked cowpea leaves. *Journal of Food Science* 48: 1252-1254.

Jalal F., M.C. Nesheim, Z. Agus, D. Sanjur, and J.P. Habicht.
1998.
"Serum retinol concentrations in children are affected by food sources of beta carotene, fat intake, and anthelminthic drug treatment." *American Journal of Clinical Nutrition,* 68: 623-629.

K'osambo, L.M., E.E. Carey, A.K. Misra, J. Wilkes, and V. Hagenimana.
1998.
"Influence of Age, Farming Site, and Boiling on Provitamin A Content in Sweet Potato (*Ipomoea batsatas* (L.) Lam.) Storage Roots. *Journal of Food Composition and Analysis,* 11: 305-321.

Low, J., E. Carey, S. Gichuki, and P. Tana.
1996.
Conducting on-farm sweet potato trials in Western Kenya: Lessons Learned. (Social Science Working Paper.) International Potato Center. Lima, Peru.

Low, J., P. Kinyae, S. Gichuki, M.A. Oyunga, V. Hagenimana, and J. Kabira.
1997.
Combating vitamin A deficiency through the use of sweet potato. Results from Phase 1 of an action research project in South Nyanza, Kenya. International Potato Center. Lima, Peru.

Persson, V., T. Greiner, I. Sirajul, and M. Gebre-Medhin.
1998.
"The Helen Keller International food-frequency method underestimates vitamin A intake where sustained breastfeeding is common." *Food and Nutrition Bulletin* 19 (4): 343-346.

Quisumbing, A., L. Haddad, R. Meinzen-Dick, and L.R. Brown.
1998.
"Gender Issues for Food Security in Developing Countries: Implications for Project Design and Implementation." *Canadian Journal of Development Studies*, vol. XIX (special issue).

Sachs, C.
1996.
Gendered Fields: Rural Women, Agriculture, and Environment. Rural Studies Series. Westview Press. Boulder, CO.

Takahata Y., T. Noda, and T. Nagata.
1993.
"HPLC determination of â-carotene of sweet potato cultivars and its relationship with color values." *Japanese Journal of Breeding* 43: 421-427.

Woolfe, J.A.
1992.
The sweet potato: An untapped food resource. Cambridge University Press. England.

USAID

The publication of this report is made possible by support from Opportunities for Micronutrient Interventions (OMNI) Research, a project of the Office of Health and Nutrition, Bureau for Global Programs, Field Support and Research, U.S. Agency for International Development (USAID), under cooperative agreement HRN-5122-A-00-3046-00. The information presented herein does not necessarily reflect the scientific recommendations or views of OMNI Research, the USAID, or the International Life Sciences Institute (ILSI).

International Center for Research on Women

1717 Massachusetts Avenue NW ■ Suite 302 ■ Washington, DC 20036 ■ USA
Tel: (202) 797-0007 ■ **Fax:** (202) 797-0020 ■ **http://www.icrw.org** ■ **e-mail:** info@icrw.org