TOWARDS SUSTAINABLE NUTRITION IMPROVEMENT IN RURAL MOZAMBIQUE: ADDRESSING MACRO- AND MICRO-NUTRIENT MALNUTRITION THROUGH NEW CULTIVARS AND NEW BEHAVIORS:

KEY FINDINGS

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By

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Southern African Root Crops Research Network, Mozambique (SARRNET)
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Undertaking this study was the fulfillment of a long-time desire to follow-up on work initiated in Western Kenya in the mid-1990s using orange-fleshed sweetpotato as an entry point for addressing vitamin A deficiency in rural sub-Saharan Africa. First and foremost, I would like to thank Venkatesh Mannar, the president of the Micronutrient Initiative (MI) of Canada for his willingness to fund an integrated food-based action research study at a time when food-based initiatives had fallen out of favor with many donors. MI's strong support encouraged others to participate. Hopefully, these findings will provide valuable lessons regarding the integration of nutritional concerns into agricultural projects in the search for effective means for addressing the underlying causes of poverty and malnutrition.

Three years is a very short-time frame to design, implement, and write-up results of an intervention that inherently depends on the agricultural cycle and unpredictable weather. It was only possible due to strong partnerships, supportive colleagues and friends, a dedicated staff, and understanding donors. Lourdes Fidalgo, former head of the Nutrition Division, was instrumental in helping to get the project initiated and provided technical support in the development of radio programs and assessment of the behavioral change strategy. Sonia Khan and Armanda Gani, both from the Nutrition Division of the Ministry of Health, assisted in providing training materials and establishing the project at the provincial and district levels. They also, along with Percina Simbine, assisted in organizing national seminars and advisory council meetings. The government provincial nutritionist Antonia Malgalhães supervised the blood collection team and Eugenia Raposo facilitated project activities with district and provincial level health authorities. Irene Langa and Avelina Mazive of the Mozambican National Institute of Health trained staff on serum retinol and hemoglobin collection. World Vision lent vehicles and provided logistic and human resource management support far beyond the services stipulated within their contract. The years of experience in Zambézia and collaborative spirit of Brian Hilton, head of World Vision's OVATA agriculture project, is much valued. Maria Andrade and Alvares Sandramo of SARRNET/INIA trained agriculture staff, provided new varietal material, and collaborated on adaptive trials, and Abdul Naico and Maria de Lourdes Faria trained all extension staff on processed products. Micheline Ntiru and Jorgette Malanzele of Helen Keller International contributed towards the refinement of the behavioral change communication strategy and market promotion strategy. District agricultural and health officers in Namacurra, Mopeia, and Nicoadala collaborated on assuring the management of multiplication plots, and the correct implementation of the health components of the research protocol, respectively. A special thanks goes to my colleague at Michigan State University (MSU), David Tschirley, for immense support and backstopping on the administrative side. Rosie Kelly and Jean Schueller of MSU spent many hours on contracts and accounts and their efforts are much appreciated. Steve Longabaugh also provided timely assistance on financial accounting as needed. MSU colleagues based in Maputo, Duncan Boughton, Ellen Payongayong, Tom Walker, and Maria Jose Teixeira, also provided much appreciated administrative and moral support.

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All donors visited the project at some stage. Cheryl Jackson of USAID-Washington came in the beginning, a team from the Micronutrient Initiative (Venkatesh Mannar, Carol Marshall, Annie Wesley and Barbara MacDonald of CIDA) at the end of 2003, and Joe DeVries of the Rockefeller Foundation and Howdy Bouis of HarvestPlus close to the end of the intervention. The research team learned something from each visit, and their first-hand experience of the poverty and social and environmental challenges the project was up against hopefully makes our findings even more exciting to them. The subsequent decisions of the Rockefeller Foundation to support OFSP breeding efforts and capacity building in Mozambique, HarvestPlus to provide funding to scale-up this pilot initiative, and the Micronutrient Initiative to join in seeking funds to expand elsewhere in Mozambique and Southern Africa are deeply appreciated. USAID's long-standing support of SARRNET in the region is also duly recognized as a base on which other OFSP-based activities can build upon.

Jan W. Low
Principal Investigator

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EXECUTIVE SUMMARY

This report presents key results from a two-year pilot intervention research project in Central Mozambique. The project aimed to alleviate malnutrition, particularly among young children, through integrating agricultural and nutrition activities. Vitamin-A-rich orange-fleshed sweet potato (OFSP) was selected as the centerpiece of this food-based intervention, as it had high potential as an acceptable and sustainable crop and food. The project, titled *Towards Sustainable Nutrition Improvement Project (TSNI): Addressing Macro- and Micro-nutrient Malnutrition Through New Cultivars and New Behaviors*, was conducted in 3 drought-prone districts in Zambézia Province. Data collection was completed in March 2005. This report presents results from the first phase of the data analysis. The TSNI project was a partnership between Michigan State University, the Nutrition Division of the Ministry of Health, World Vision-Mozambique, Helen Keller International, the Southern African Root Crops Research Network (SARRNET), and the National Agronomic Research Institute of Mozambique (INIA). The study was financed by the Micronutrient Initiative, the Rockefeller Foundation, USAID-Washington, and HarvestPlus.

More specifically, the TSNI ultimately aimed to increase intakes of vitamin A and energy, particularly among young children (6 months to 4 years of age), and also to increase serum retinol for this vulnerable age group. The pathway between agricultural interventions and child nutrition outcomes is complex. In order to ultimately achieve increases in intakes and serum retinol, a number of intermediary objectives must be met and activities were undertaken towards meeting three of these:

1) Improved access to high-yield orange-fleshed sweetpotato (OFSP) varieties that are rich in beta-carotene (the precursor to Vitamin A);

2) Increased demand for OFSP and enhanced knowledge and child-feeding practices of caregivers through extension service contact and use of media; and

3) Enhanced incomes through expansion of area under production and development of markets for fresh OFSP roots and their processed products.

The combined results of pilot activities and research indicate that OFSP can significantly improve intake of vitamin A among rural populations, and represents an attractive and sustainable complement to vitamin A capsule distribution.

Ethical Review

In developing countries such as Mozambique, where diets are low in vitamin A and children suffer from high levels of morbidity, the recommended practice is to distribute vitamin A capsules every six months. The study protocol was designed to test the success of the food-based intervention in *maintaining* adequate serum retinol status in young children who were given vitamin A capsules at the outset of the study. The study protocol was reviewed and approved by the ethics review committees of its major donor, the Micronutrient Initiative of Canada, the University Committee on Research

Involving Human Subjects of Michigan State University of the United States of America and the National Bioethics Committee for Health of Mozambique.

Extension and Data Collection Activities

The introduction of OFSP, accompanied by a promotion campaign and use of extension services to increase demand for OFSP, operated during four potential growing seasons for OFSP, the 1st and 2nd season in 2003 and the 1st and 2nd season in 2004. Four male agricultural extensionists worked with 53 farmers' groups to support distribution, cultivation, and preservation of vines. Four female nutrition extensionists worked with the same farmers' groups using a variety of communication techniques (demonstrations, flipcharts, and others) to inform caregivers and encourage behavioral change. The communication strategy also included radio programs, community theater, prizes of promotional hats and *capulanas* (lengths of cloth worn as skirts), and market-based advertising to create an enabling environment for modifying behaviors and to create demand for OFSP and other vitamin A-rich foods.

Intervention villages were selected prior to control villages so that the latter could be matched as closely as possible in terms of agro-ecological conditions. In both intervention districts (Mopeia and Namacurra) and the control district (Nicoadala), villages within a given agro-ecology were stratified by distance to services and were then randomly selected, and all families with children under 3 years of age were invited to participate in the study. In intervention areas, participation in the study required participation in the farmers' groups, and new groups were formed as needed. Baseline data collection was concluded in June 2003; and, of the 827 households initially enrolled in the study 90% (741 households) completed the study. The final sample included 498 households in the intervention districts, and 243 in the control district. In the intervention areas, there were two distinct nutrition interventions made. In type I, community nutritionists held monthly group sessions, whereas in type II, in addition to the group sessions, home visits were made every other month to participating female caregivers in the study. In the final sample, 49% of the principal female caregivers were in the type I intervention (246 households), compared to 51% in the type II intervention (252 households).

Integration of the data collection with the extension activities over a two-year period was carefully planned to ensure completion of activities within the allotted time frame. Four rounds of data collection were conducted on nutritional status and morbidity, and two rounds were collected on consumption (both at household- and individual reference child level (24-hour recall)), and on food and non-food expenditures during the principal harvest season. Baseline and final round data were collected on socio-economic status indicators, production, and nutritional knowledge of principal caregivers in the household. Data concerning fertility history of the mother of the reference child, use of health facilities, and patterns of radio use were collected during the course of the study. Frequency of consumption of vitamin A rich foods by the reference child was collected seven times throughout the study to capture seasonal patterns.

The key outcome variable for vitamin A status, serum retinol, was measured four times at 5.5-6.5 month intervals for all intervention children and three times (Baseline (Round

1), Round 2 and Round 4) for all control children. Because both chronic and acute infections can depress serum retinol independently of dietary deficiencies, it is necessary to account for the influence of infection when using serum retinol to assess vitamin A status. Therefore, in addition to serum retinol, two acute phase proteins were measured. These two proteins function as markers for infection. C-reactive protein (CRP) was measured at rounds 1, 2 and 4, and α_1-acid glycoprotein (AGP) was measured only in Round 4.

Characteristics of the Sample at the Beginning of the Study

At baseline, all recruited *reference children* were under 39 months of age (mean age 17 months) and their principal female caregivers were their biological mothers (mean age 28 years). By the end of the study, 15 of the biological mothers were no longer present. Eleven percent of study households never had any principal man (a man who had responsibility for the care of the reference child) resident during the entire study, but 76% had the same principal man throughout the study.

Few significant differences in socio-economic status indicators existed between intervention and control households. The study area is characterized by poor sandy soils and undependable rainfall, with most families depending on non-agricultural self-employment activities and casual labor as principal sources of cash income. The principal staples in the diet in these low altitude areas are cassava, rice, sweetpotato and maize. Diets are not diverse, with consumption of vegetables and animal source foods, except fish, being particularly low. Housing and sanitation conditions are poor. Only 3% of households had latrines and half of the main sleeping dwellings were found to be in poor condition. Over 1 million households were displaced in Zambézia during the 17-year civil war that ended in 1992. Consequently, rural services are poor and civil society suffers from lack of trust. There are few community-based organizations, except religious institutions. Sixty-one percent of the principal female caregivers never attended school, and only a fifth had more than two years of formal education.

Levels of malnutrition and morbidity among young children were extremely high at the beginning of the study. No significant differences existed between intervention and control children at baseline in terms of serum retinol status or prevalence of stunting. At baseline, 71% of the 741 reference children had low serum retinol (<0.70 µmol/L)[1] and over half were stunted. Prevalence of wasting was significantly higher in control children (11%) than intervention children (6%). Eighty-one percent of reference children suffered from some kind of illness during the two weeks prior to the baseline survey and 64% of children had elevated CRP (>5 mg/L), indicating acute infection, at baseline.

These Baseline results on child nutrition confirmed and underscored a pressing need for interventions aimed at providing families with new resources and capabilities. Baseline results also confirmed that interventions must be adapted to the needs of poor

[1] As noted, serum retinol can be depressed during infection with or without vitamin deficiency; among the subset of baseline children who did not have elevated CRP (n = 264 “healthy” children) 58% had low serum retinol, indicating vitamin A deficiency was widespread.

households in a resource-poor environment. Finally, low education levels, particularly among women, would influence the type and complexity of the intervention that could be employed.

The next several topics review the results pertaining to each of the three intermediary objectives listed above: i.e., improving access to OFSP; increasing demand and enhancing knowledge and practices through extension; and increasing income through market development and expanded production. Then we present positive preliminary results for the two main outcomes of interest: child dietary intake and serum retinol.

Increasing Sustainable Access to High-yielding, Beta-Carotene-Rich Varieties

Adoption, Adaptive Testing, and Breeding of Orange-Fleshed Sweetpotatoes
Five of the nine introduced OFSP varieties (Resisto, Jonathan, CN-1448-49, LO 323, and Japon) were accepted by farmers, both men and women, in terms of taste and agronomic performance in a difficult agro-ecological setting. Households responded to market and production incentives by expanding the area under production in year two, increasing average plot sizes by approximately 10 times, from 33 to 359 square meters.

Resisto emerged as the most popular of the nine introduced OFSP varieties because of its good taste and appearance, good yields relative to other OFSP and local varieties, prostrate (spreading) growth structure, and tendency to produce the medium-sized (200-300 gm) roots preferred by the commercial market. Jonathan, CN-1448-49 and LO 323, however, are more resistant to drought conditions. Although their erect growth structure is not preferred by producers, their vines are hardier and more likely to be retained for subsequent plantings under harsh drought conditions. On-farm yields of sweetpotato range from 6-15 tons/hectare under the poor soil and rainfed growing conditions of the Low Altitude zone of Zambézia Province. Eighty-six percent of intervention households reported that OFSP was higher yielding than local white-fleshed varieties. However, crop cuts indicate that yields vary considerably across sites and overall it is best to consider yields between the local and the best introduced clones as comparable under poorer rainfall conditions, with OFSP being superior under normal rainfall conditions (yields of 10-15 tons/hectare).

OFSP varietal development is an on-going process. During adaptive trials of new OFSP varieties, several local varieties such as Canasumana were identified that have superior vine vigor than Resisto under drought stress. These varieties should be crossed in Mozambique with the most popular prostrate, dark intensity OFSPs (Resisto and Cordner) to strengthen the adaptability of the latter to agro-ecological conditions in Zambézia. Implementation of this recommendation began in 2005 under SARRNET/INIA with the expectation that in five years OFSP material superior to existing clones in terms of drought resistance will be released. In the interim, the most promising new materials from the adaptive trials conducted during the past two years will be nominated for official release and distribution (440215, TIB4). These new OFSP varieties, along with five most popular released varieties being successfully deployed at the current time (Jonathan, LO-323, Resisto, CN-1448-49, and Japon), should continue to be promoted in Mozambique based on a modified integrated conceptual framework that incorporates the proposed more commercially-oriented vine multiplication and dissemination strategy. This will assure the sustained cultivation and increased commercialization and diversified use of OFSP in drought-prone areas of Mozambique.

Sustaining Access to Improved Material

Developing sustainable planting material dissemination systems emerged as the most challenging aspect of the OFSP intervention in areas with 3-6 months of drought risk during the year. The two most common methods of vine retention by farmers during the driest parts of the year are planting in valley bottoms with sufficient residual moisture to sustain the vines, and leaving some roots in the ground to re-sprout when the next rain comes. The drawback to the latter approach is that farmers typically have a limited amount of material emerging when the first rains comes, which results in small plots of sweetpotato being produced. Most households lacking sufficient planting material traditionally have obtained cuttings from their neighbors.

Since vegetatively propagated crops like sweetpotato can be spread informally by farmers, there is little incentive for involvement of the formal seed sector. In economic terms, such crops are often considered to be public goods, reliant on government or non-profit institutions for their propagation and dissemination. Hence, as in this pilot, vines are often distributed free to farmers with the cost born by the distributing agency.

The pilot effort found that rapid multiplication plots, where vines can be harvested after six weeks, require substantial labor input beyond the capacity of farmers' groups lacking easy access to a water supply. Conventional multiplication is less labor intensive, but requires greater amounts of land than rapid multiplication and vine ability is delayed. Pilot experiences in year two with manually operated treadle pumps as a management tool for rapid multiplication plots were promising. Moreover, farmers were willing to pay for vines sold by traders in pilot trials in local markets. The major constraint to area expansion of OFSP was timely availability of vines in adequate quantities. Findings indicate that consideration should be given to testing dissemination strategies based on the establishment of decentralized, commercialized vine sales managed by local farmers or community institutions with access to adequate water supplies.

Increased Demand and Enhanced knowledge: Farmer Extension

The extension approach emphasized joint planning by agricultural extensionists (all men) and nutrition extensionists (all women); with both agents working with the same farmers' groups within their area (53 groups for the entire study; composed of 323 men and 718 women in 2003), and holding group sessions 2-3 times per month (depending on the season). The intervention households were divided into two sub-groups: caregivers receiving an additional six home visits and those not receiving any home visits from the nutrition extensionist.

Nutrition knowledge increased among both men and women and in both intervention and control areas. However, increases were larger among intervention than among control women. Note also that while control households did not participate in farmers' groups, other communication strategies—radio, community theater, and market-based advertising—could reach them. Intervention mothers and fathers showed particularly improved knowledge of vitamin A-rich foods, optimal breastfeeding practices, and optimal complementary feeding practices.

Preliminary findings indicate 1) no significant improvement in women's nutritional knowledge score due to receiving additional home visits, and 2) no significant difference in serum retinol status or vitamin A intake between children of caregivers receiving or not receiving home visits. However, intake levels for many other key nutrients consumed by the child were significantly higher in those households receiving home visits compared to those not receiving.

Farmers' groups actively participated in on-farm trials of new OFSP varieties and taste tests, with agriculture extension agents recording farmer preferences for different characteristics. Extension agents noted the higher rates of interest in better agronomic practices, particularly for controlling for weevil infestation, when farmers could obtain a higher price for better quality OFSP through the pilot grading scheme.

Processing sweetpotato into dried chips extends its availability throughout the year and the recommended method builds on an existing traditional practice. Farmers were encouraged to dry under the shade of a tree instead of under direct sunlight to preserve beta-carotene content. In 2004, 39% of intervention households dried OFSP and 75% of those followed the recommended practice of shade drying. Samples of chips dried under local conditions showed good beta-carotene content for the darker orange-fleshed Resisto variety (ranging from 716-1,050 µg RAE/100 gms) and much lower content in light orange-fleshed CN-1448-49 (165-191 µg RAE/100 gms). Therefore, use of darker orange-fleshed varieties such as Resisto for chipping and drying is superior to use of light orange-fleshed varieties like CN-1448-49. However, contrary to expectations, the beta-carotene in the samples dried in direct sunlight was not completely destroyed. Average levels for Resisto were only 21% lower in direct sunlight than for treatments not in direct sunlight.

Expanded Production, Market Development and Increased Incomes

A key challenge was to devise a system that encouraged households to produce surplus production, but at the same time assured sufficient home consumption. This was a particular challenge in those localities where men, rather than women, had more decision-making power concerning sales of OFSP.

The pilot concept tested in year two consisted of constructing a market booth decorated with promotional messages in a highly accessible location for both producers and purchasers of OFSP, enhancing the trading skills of a local small-scale trader, and contracting that trader to follow purchasing rules established by the project in exchange for exclusive use of the decorated booth and assistance by extension staff in establishing links with farmer's groups producing OFSP.

The guiding principle underlying the strategy was to introduce the concept of quality grades, whereby 1st quality OFSP is purchased for a higher per unit price than 2nd

quality OFSP, and OFSP not achieving 2nd quality status is never purchased, nor is white-fleshed local sweetpotato. This strategy sought to create a new and exclusive market for OFSP based on its visible trait, while at the same time guaranteeing that a significant quantity of OFSP remains for home consumption.

The trained trader successfully implemented the grading scheme to financially reward farmers for higher quality OFSP. Farmers responded to the presence of a buyer and other project promotional activities by significantly expanding area under production. Whereas no intervention households had OFSP plots over 500 square meters in size in 2003, 35% did in 2004. The trader purchased over 3.3 tons of OFSP and had a gross margin of 188 USD for the 6-month season.

From the consumer standpoint, OFSP emerged as a relatively inexpensive source of calories and a very cheap source of vitamin A in the Zambézian food system. On average, OFSP was the 2nd cheapest source of vitamin A in local markets in 2003 (60 MT (0.25 cents) per 100 Retinol Activity Equivalent (RAE) units), and the cheapest in 2004 (34 MT (0.14 cents) per 100 RAE units). In 2004, meeting the RDA for a child less than 6 years of age with OFSP cost less than 1 cent per day.

The conceptual framework hypothesizes that greater awareness of the importance of vitamin A-rich foods, combined with increased incomes from the sales of sweetpotato roots, will lead to purchase of more vitamin A-rich foods in the market place, which in turn will contribute to increased vitamin A intake. While mean monthly expenditures on vitamin A-rich foods during the main harvest season in intervention households increased slightly between 2003 and 2004, no significant differences in expenditure on vitamin A-rich foods was seen between intervention and control households in either year. In these resource-poor households, priorities for cash purchases are concentrated on food and non-food products essential for meeting basic needs that cannot be produced on-farm. Since some of the vitamin A-rich foods can be produced on-farm (OFSP, papaya, and pumpkin being the most common), the perception appears to be that scarce cash resources do not have to be spent to buy different kinds of vitamin A-rich foods than those that are produced. The one vitamin A-rich source that is frequently purchased, fresh fish, was already part of the existing food expenditure pattern at the beginning of the study.

Four recipes for OFSP-based processed products developed by TSNI partner SARRNET/INIA were adapted for the Zambézian market. The most popular and profitable product produced proved to be *Golden Bread*, in which 38% of wheat flour is substituted with boiled and mashed OFSP. Bread is one of the first processed products produced in rural markets when wheat flour is available and is widely consumed by the rural poor in small amounts when available for purchase. Golden bread increased profit margins of bakers in the three pilot test sites by from 50% to 92%. The majority of consumers preferred golden bread to white bread because of its heavier texture and golden color. Laboratory analysis conducted by Paul Jaarsveld of the Medical Research Council in South Africa on bread samples from five OFSP varieties showed that dark orange-flesh varieties like Resisto produce buns with sufficient trans-beta-carotene content to be considered excellent sources of vitamin A for young children and good sources for adults. For a child 1-3 years of age, a small bun of 60 gms made with

Resisto would contribute 25% of daily vitamin A needs, whereas a medium-sized bun of 110 gms provides 45%.

Impact on Child Vitamin A Dietary intake and Serum Retinol

Results indicate that the intervention succeeded in improving diet diversity, caloric and vitamin A intake at the household level and among reference children during the post-harvest period (August-October), which coincides with the main sweetpotato production period. At the end of the two-year period, the average age of children in the study area was 32 months, with no significant differences in the age and sex composition between intervention and control children. Based on the 24-hour recall, 35% of intervention, and 3% of control children ate OFSP the previous day. **Median intake of vitamin A was 8.3 times higher among intervention than among control children.** Given that the Recommended Dietary Allowance (RDA) for children 1-3 years of age is 300 μg retinol activity equivalents (RAEs) and 400 μg RAEs for children 4-6 years of age, 100 grams of medium or darker intensity OFSP could easily provide the RDA. Median values were 468 μmol/L for intervention children compared to only 56 μmol/L for control children.

The project achieved its objective of increasing vitamin A intake among young children through the introduction and promotion of OFSP, but not exactly as designed. The promotional message emphasized trying to feed at least a small amount of OFSP every day. In practice, children over one year of age ate large amounts (2 medium-size sweetpotato, 300 gms on average) 2-3 times per week coincident with the normal consumption practices among adults in the study area.

The project also achieved its objective of increasing energy intake among young children, which is most likely due to an increased number of meals per day. **Median energy intakes in the intervention areas (1339 kcal) exceeded control values (1225 kcal) by 14.2%.** More intervention than control children consumed breakfast, and OFSP was principally consumed as a breakfast food, probably due to ease of preparation and the common perception of sweetpotato as a bread substitute. OFSP contributed on average 6% of energy intake among intervention children. Moreover, OFSP also significantly contributed to young child intake of vitamin C, vitamin E, vitamin K, and all B-vitamins, except vitamin B12, in intervention areas.

The project also aimed, as a secondary objective, to increase fat intakes. This did not occur, even though groundnut seed was distributed during the second year of the intervention. Also, one of the key nutrition messages promoted the addition of a small amount of fat to each of the child's main meals. However, agro-climatic conditions restricted the kind and quantity of fat-rich crops non-coconut growing households could produce and limited purchasing power restricted purchase of fat-rich foods in the market. The result is that the average percentage of calories contributed by fat is only 12% among all study children, far below desired levels of 30-35%. Intake findings are summarized in the table on the following page.

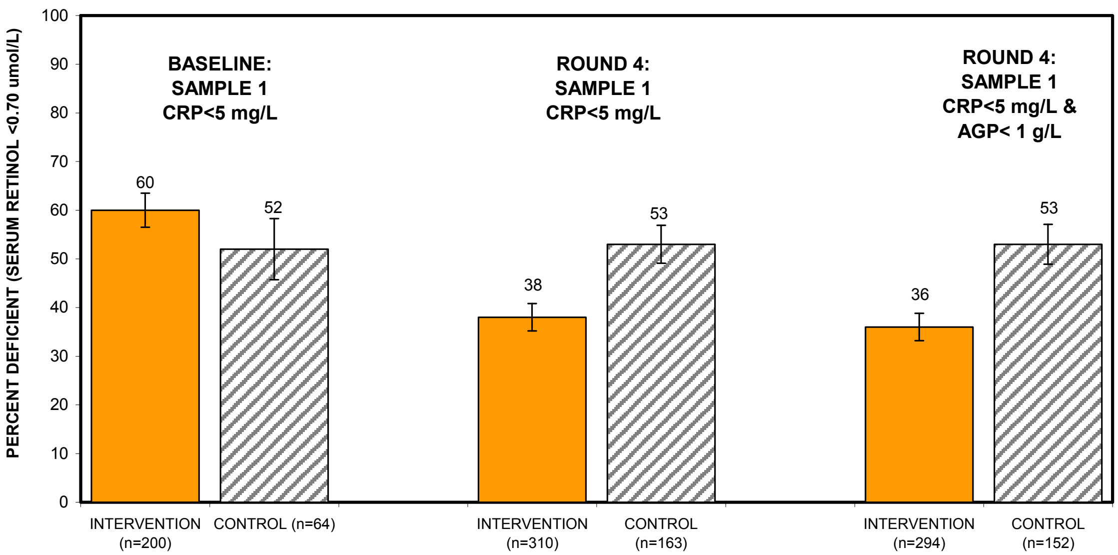
SUMMARY OF KEY CHARACTERISTICS OF REFERENCE CHILD NUTRIENT INTAKE IN FINAL ROUND

	INTERVENTION (N=498)	CONTROL (N=243)	P-VALUE
MEAN ± SD OFSP INTAKE** (days/week)	2.8 ± 2.7	n.a.	
MEAN ± SD OFSP INTAKE* (gm/day)	104 ± 174	7.1 ± 46	0.000
VITAMIN A INTAKE (ug RAE/day)* --MEAN ± SD	1074 ± 1413	180 ± 400	0.000
--MEDIAN	468	56	0.000
% MEAN VITAMIN A FROM OFSP*	31%	3%	0.000
ENERGY INTAKE: MEAN ± SD kcal/day*	1455 ± 566	1268 ± 459	0.000
FAT INTAKE: MEAN ± SD gm fat/day*	21.6 ± 18.9	19.3 ± 17.5	0.119

Note: SD = Standard deviation OFSP = Beta-carotene-rich Orange-fleshed Sweetpotato
* Intake levels based on 24 hour recall survey from August-October 2004 that does not include estimates of breast milk consumption for the 9.6% of reference children still breast feeding at that time. Mann-Whitney U non-parametric tests show significant differences between study areas when p-value <0.05.
**Recall information on frequency of intake per month from June-November 2004 collected during final survey round (November 2004-January 2006).

Serum retinol results comparing baseline status and end of study status 18 months later indicate that vitamin A deficiency[2] was substantially reduced from 60% to 36% or by 24 percentage points among healthy intervention children in an extremely resource-poor environment (refer to figure below). A comparable reduction did not take place among healthy control children, over half of whom remained deficient at the end of the study. These results suggest that the differences seen in levels of deficiency and intake of vitamin A between intervention and control areas may be attributed to the intervention.

PERCENTAGE OF APPARENTLY HEALTHY CHILDREN DEFICIENT IN SERUM RETINOL AT BASELINE AND FOR ROUND 4 BY SAMPLE DEFINITION AND BY AREA



NOTE: Definition of apparently healthy child based on absence of elevated acute proteins measured in particular round.
Sample 1 consists of all children completing study except 8 intervention children receiving capsules between round 2 & round 4.

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2 Vitamin A deficiency is commonly defined as the percentage of children with serum retinol values less than 0.70 μmol/L.

CONCLUSION

In conclusion, the pilot intervention-research project demonstrated that it is possible to significantly increase vitamin A intakes and reduce the prevalence of low serum retinol among young children using an integrated approach based on the introduction of OFSP. The large reduction in prevalence of low serum retinol was achieved despite the extremely poor sanitary and health conditions found in the study area; these conditions result in high levels of morbidity and constrain the potential of any intervention. The impacts on knowledge, adoption, agricultural, and child-feeding practices, intakes and ultimately on serum retinol were also obtained over what constitutes a very short timeframe for an agricultural and behavior change intervention. Subsequent regression analyses will enable us to investigate and measure the contribution of various biological, socio-economic, demographic, production, and consumption factors to this difference.

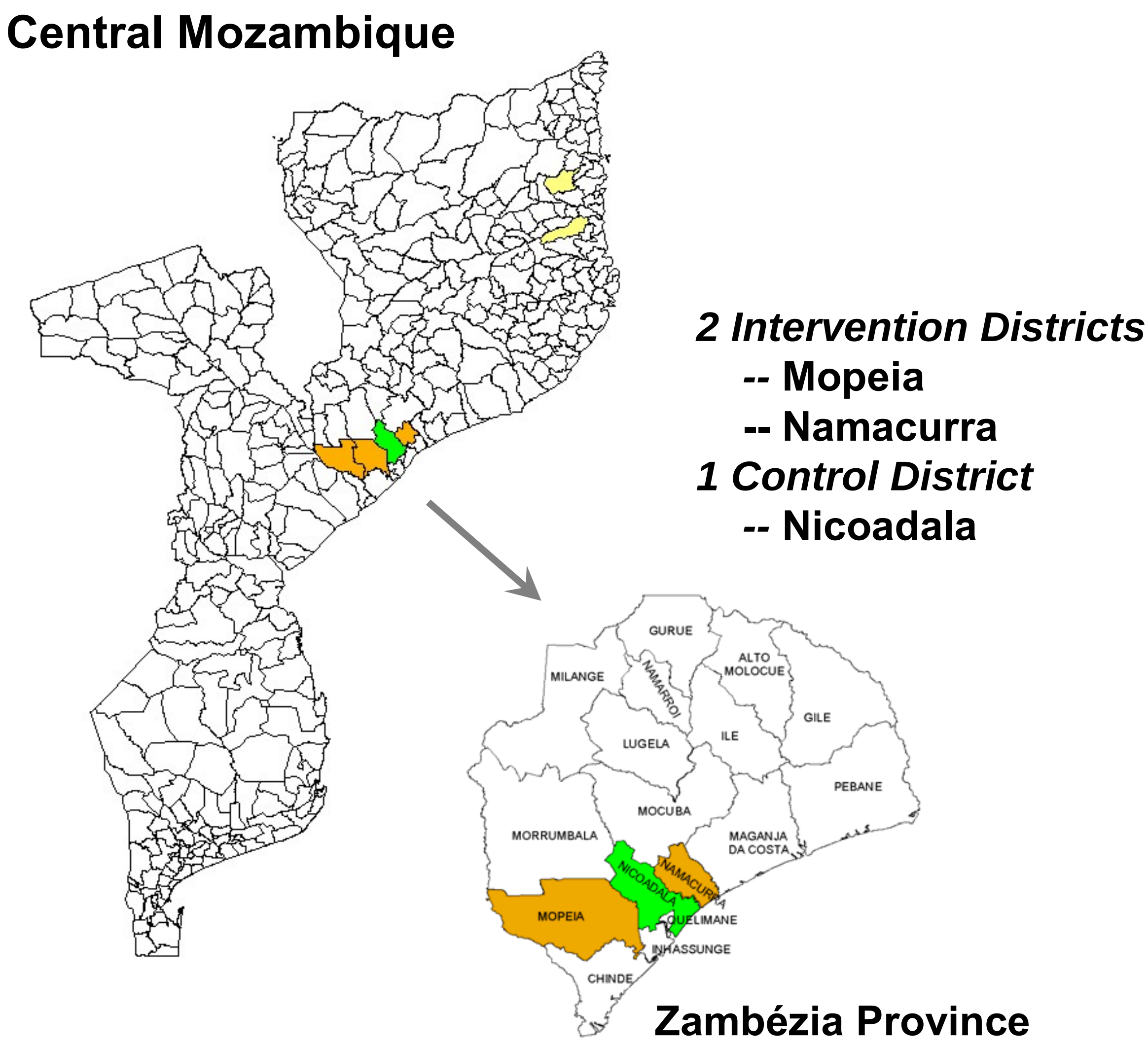
In the medium term, we recommend that breeders focus on producing dark intensity OFSP varieties that are more drought-tolerant. In the meantime, for the short-term programs can continue to promote the best existing OFSP varieties, with emphasis given to developing decentralized, small and medium-sized commercialized vine multiplication enterprises, thereby ensuring adequate vine supply for increased adoption and area expansion.

Given the persistent high morbidity levels and their consequent impact on constraining adequate nutrient intake and absorption, and hence child growth, consideration should be given to linking the TSNI intervention with health service delivery programs and other community-based health and sanitation endeavors.

MAP 1. THE STUDY AREA

ZAMBĖZIA PROVINCE

CENTRAL MOZAMBIQUE



1. INTRODUCTION

The *Towards Sustainable Nutrition Improvement Project* (TSNI) was an action-research project that has sought to address two major nutritional problems among children under five years of age: vitamin A deficiency and inadequate caloric intake. The "action" component consisted of an extension program linking the introduction and promotion of orange-flesh, beta-carotene rich sweetpotato (OFSP) varieties as a low-cost dietary source of vitamin A with a concurrent effort to alter the child feeding practices of the principal caregivers of children under five through a behavioral change communication (BCC) program. The BCC program based nutrition extension agents in communities to work alongside their agricultural counterparts and promote broader community awareness through the use of radio programs, community theater and painted walls with relevant messages in key markets. The research component focused on obtaining relevant data to permit eight key questions to be answered concerning the agriculture-nutrition-communication intervention:

1) Were the introduced OFSP varieties acceptable to both producers and consumers in terms of agronomic performance and organoleptic qualities?
2) Did participant households process sweetpotato and diversify its use?
3) Did the intervention result in increased levels of nutritional knowledge among both female and male principal caregivers in the household?
4) Is the increased awareness of the importance of vitamin A rich food reflected in changes in food purchasing patterns?
5) Did the intervention result in improved diet diversity and increased caloric and vitamin A intake at the household level?
6) Did the intervention result in improved caloric and vitamin A intake in children less than five years of age?
7) Is there significant improvement in vitamin A status, as measured by serum retinol, in children participating in the intervention areas compared to those not receiving the extension intervention in the control areas?
8) To achieve change in vitamin A intake and overall serum retinol status, is it necessary to make home visits to principal female caregivers of young children or are group level extension visits sufficient?

1.1 Overview of Study Sample and Types of Information Collected

The extension component of the project operated over two years, covering four potential growing seasons for OFSP, the 1st and 2nd season in 2003 and the 1st and 2nd season in 2004. Baseline data collection was concluded in June 2003 and of the 827 households initially enrolled in the study 90% (741 households) completed the study. The final round of data collection ended in March 2005[3]. Table 1.1 cites the reasons for failure to

[3] The original proposal specified a final desired sample size of 750 households, 500 in the intervention areas, 250 in the control areas. The final number of dropped households is quite close to the anticipated

complete the study. The most common reason was due to the death of the reference child (37 cases), closely followed by the household or the child leaving the study area (32 cases). In only 13 cases did families refuse to continue in the study.

TABLE 1.1 TSNI PARTICIPATION AND REASONS FOR NOT COMPLETING THE STUDY

	FREQUENCY	PERCENT
COMPLETED THE STUDY	741	89.6
DEATH OF THE REFERENCE CHILD	37	4.4
HOUSEHOLD OR MOTHER/CHILD PAIR LEFT THE STUDY AREA	32	3.9
REFUSED TO CONTINUE	13	1.6
MOTHER VERY ILL (EITHER PHYSICALLY OR MENTALLY)	3	0.4
MOTHER DIED AND CHILD SENT TO STAY WITH ANOTHER FAMILY	2	0.2
TOTAL	827	100

TABLE 1.2 NUMBER OF PARTICIPANTS COMPLETING TSNI STUDY BY DISTRICT, STUDY AREA and TYPE OF INTERVENTION GROUP

DISTRICT		STUDY AREA		TYPE OF INTERVENTION GROUP	
		INTERVENTION	CONTROL	GROUP EXTENSION SESSIONS ONLY	HOME VISITS & GROUP EXTENSION SESSIONS
MOPEIA	252	252		129	123
NAMACURRA	246	246		117	129
NICOADALA	243		243		
TOTAL IN EACH CATEGORY	741	498	243	246	252

Table 1.2 shows the distribution of sub-groups within the final sample between districts, and between types of nutrition intervention strategies. In the intervention areas, there were two distinct nutrition interventions made. In type I, community nutritionists held monthly group sessions, whereas in type II, in addition to the group sessions, home visits were made to participating female caregivers in the study every other month. In the final sample, 49% of the principal female caregivers were in the type I intervention (246 individuals), compared to 51% in the type II intervention (252 individuals).

attrition rate. Of the 741 households who completed the study, 731 have a complete set of data, with 10 missing one of the non-critical survey modules during the course of the two-year study.

Integration of the data collection with the extension activities over a two-year period was carefully planned to ensure completion of activities within the allotted time frame. Figure 1.1 provides a calendar showing the integration of research and intervention activities. Four rounds of data collection were conducted on nutritional status and morbidity, and two rounds collected on consumption (both at household- and individual reference child level (24-hour recall)), food and non-food expenditures during the principal harvest season. Baseline and final round data were collected on socio-economic status indicators, production, and nutritional knowledge of principal caregivers in the household. Data concerning fertility history of the mother of the reference child, use of health facilities, patterns of radio use were collected once. Changes in the demographic status of the household and frequency of reference child consumption of vitamin A rich foods during the week prior to the survey were part of every survey module.

Data were entered as each module was completed. All data were double-entered using CSPRO and data entry for all modules was completed in mid-April 2005. Results from Craft Laboratories (North Carolina, USA) for the last round of serum retinol samples also arrived in mid-April. Data cleaning and analysis is now in progress, with databases and results from earlier surveys needing to be adjusted to include only those households who completed the study. Thus, in this report, we are focusing on key results from the study that address research questions 1 through 8 stated above. This analysis focuses on comparing intervention and control households to provide stakeholders with insights concerning the key findings to date. More detailed regression analysis will be conducted in the coming months.

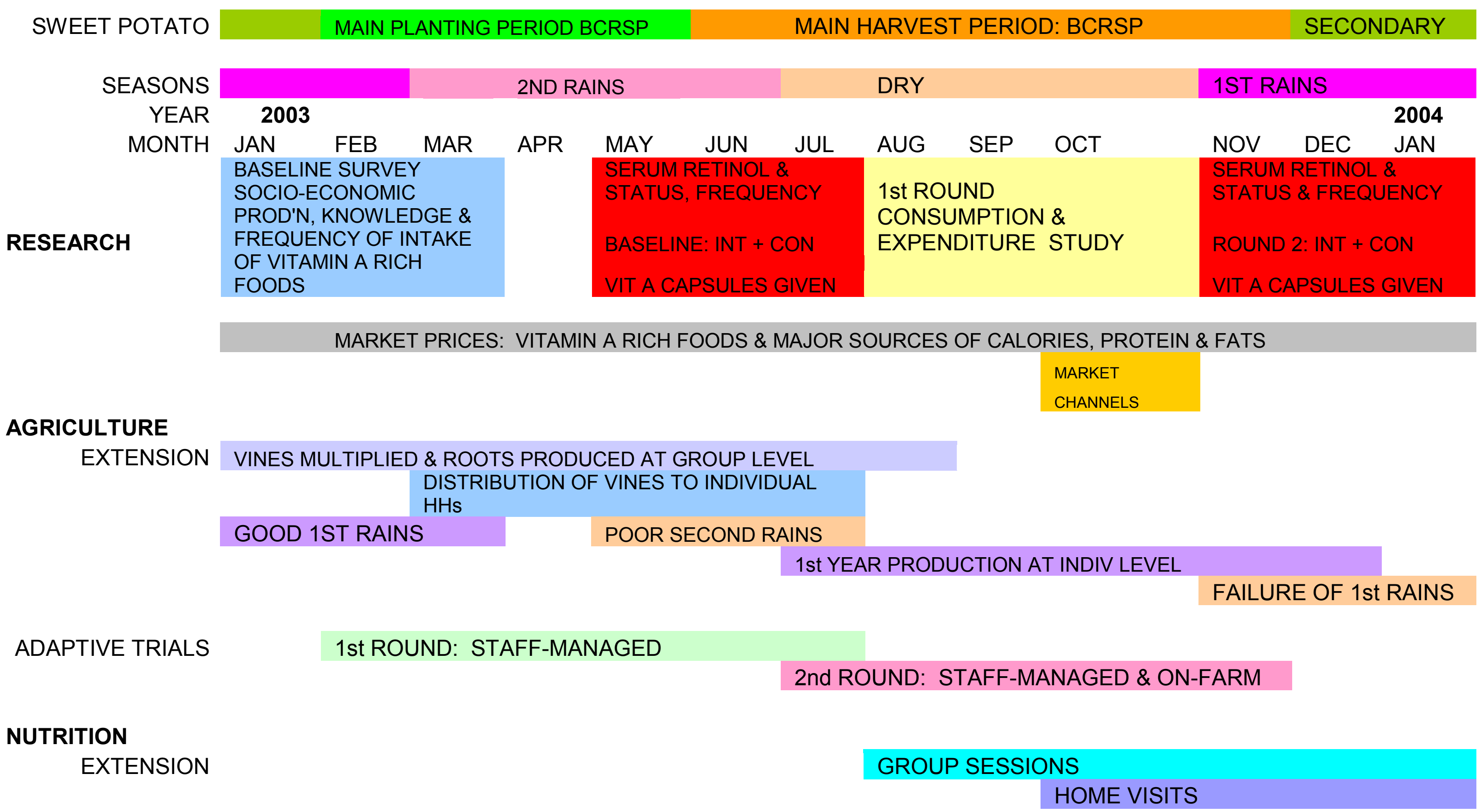
1.2 Summary of Key Characteristics of Study Sample at Baseline

This section summarizes key characteristics of the study households at Baseline. Baseline data were collected from January through May 2003 on 827 study households. For further details and relevant tables concerning Baseline characteristics consult the first year Technical Report by Low and Tschirley, 2003. Few significant differences existed in socio-economic status indicators between intervention and control households at Baseline, with the exception of control households having greater access to formal and informal salaried employment than intervention households due to their closer proximity to the provincial capital, Quelimane.

Mean household size at Baseline was 5.2 members, with little variation between intervention and control areas. This was larger than the average for Zambézia province reported in the 1997 census (3.95 members) as the study specifically selected households with young children (INE, 1999). Household size ranges from 2 to 10 members, with only 2% of study households consisting solely of the mother and child pair. The average dependency ratio is 0.55, and 28% of households have ratios exceeding 0.65.

Eight-four percent of households were headed by a male. In contrast, almost 10% of households were headed by women receiving no help from a non-resident male (*de jure* female-headed households), while 6% of households were headed by women who did receive assistance from a non-resident male.

FIGURE 1.1
TIMING OF RESEARCH AND EXTENSION ACTIVITIES: 2003-2005



TSNI: TIMING OF RESEARCH AND EXTENSION ACTIVITIES: 2003-2005, CONT.

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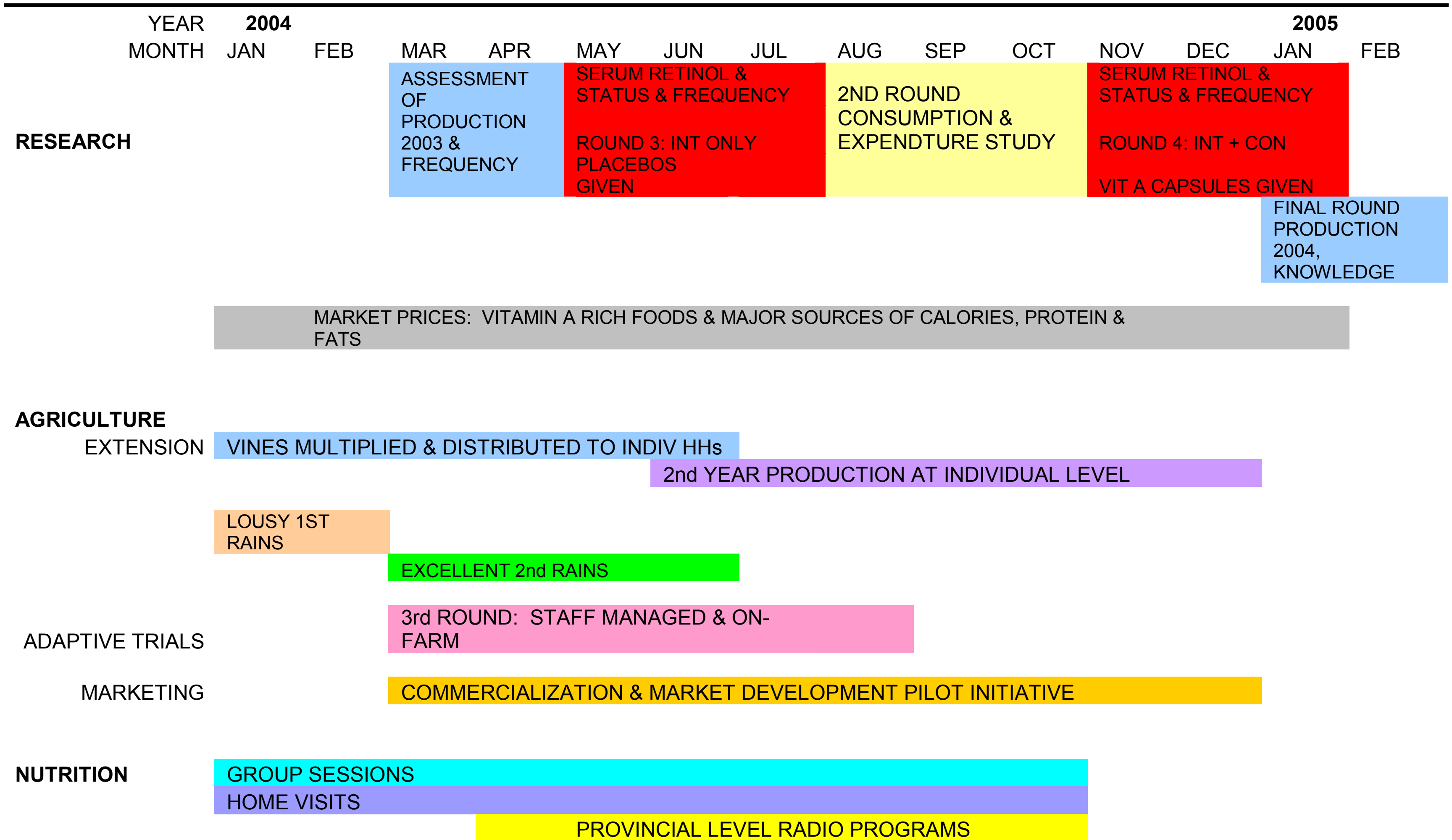


All reference children enrolled in the study were under the care of their biological mothers at Baseline. There were few differences in the characteristics of the mothers in the intervention and control areas at Baseline. In general, a high percentage of the mothers could be classified as uneducated, married, and principally engaged in agricultural activities. Sixty-one percent of mothers had never attended school, and only a fifth had more than 2 years of formal education. Only 31% of mothers spoke Portuguese. The mean age of mothers in the sample was 28 years, 39% being under 25 years of age with an overall average of four live births per mother. By the end of the study, 15 of the biological mothers were no longer present, either due to death (6 cases) or marital breakup. In the majority of these cases, a grandmother was the principal caregiver. Hence, the term *principal female caregiver* is used throughout the report.

Levels of malnutrition and morbidity among young children were extremely high at the beginning of the study. No significant differences existed between intervention and control children at Baseline in terms of serum retinol status or prevalence of stunting. At Baseline, 71% of the 741 reference children had low serum retinol (<0.70 μmol/L) and over half were stunted. Prevalence of wasting was significantly higher in control children (11%) than intervention children (6%). Eighty-one percent of reference children suffered from some kind of illness during the two weeks prior to the Baseline survey and 64% of children had elevated CRP (>5 mg/L), indicating acute infection, at Baseline.

Child malnutrition has many determinants, of which intake and morbidity are among the most important. Intake of vitamin A rich foods, of which small fish and dark green leaves were the most common, was very limited. The number of times young children of different ages are fed per day for the majority of households fell below recommended values, particularly for children 6-18 months of age. For example, a crawling, breast feeding child should be receiving 3 meals a day. However, 44% of mothers felt once a day was appropriate. Thirty-nine percent of mothers responded twice a day. Only 15% of women said crawling children should be fed three or more times a day. The high incidence of diarrhea, fever, and other ailments likely contributed to poor absorption and loss of nutrients after ingestion.

A significant number of mothers at the time of the Baseline survey were not specifically preparing complementary foods for their children under two years of age. Only three quarters of mothers with children 6-11 months old were regularly preparing porridges (*papas*) for them. This percentage dropped to 44% for mothers of children 12-17 months of age and to 37% for children 18-23 months of age. Typical porridges consisted of cassava, maize, or rice gruel, with no added sources of protein or fat, except coconut milk in the coastal areas upon occasion. Some women added sugar on a regular basis. Children not receiving specific complementary foods were relying on sharing part of the normal family diet.

At Baseline, 86% of study households had a man living in the household contributing to the care and well-being of the reference child, the so-called *principal man*. Of these, 80% (663 individuals) were the biological fathers of the reference child. The mean age of the principal men was 34 years, with 18% of the men being less than 25 years of age. A quarter had no formal schooling, but over a half had studied formally for more than two years. Consequently, almost 80% of the principal men spoke Portuguese.

Agriculture was also the dominant activity of principal men. However, higher numbers of principal men than women engaged in a diverse set of strictly non-agricultural activities, reflecting the difficult agro-ecological conditions of the study area. Participation rates of men in various activities varied between control and intervention zones. Almost 18% of men in control areas had regular salaried employment compared to just 7% in intervention areas. Control areas also had a higher percentage of men at Baseline working as casual laborers (49% vs 38%, respectively). Both areas had similar levels of participation in self-employed non-agricultural activities – 72% of men in the study areas engaged in at least one such activity (fishing, brewing, carpentry, etc.)

Self-employed non-agricultural activities were the most important sources of income in both intervention and control areas. Fifty-five percent of intervention households and 59% of control households cited these activities, which include charcoal manufacture and sale, brewing, petty trading, self-employed construction activities, etc., as their most important source of household income. Second in importance is paid labor, with 15% of intervention households and 22% of control households mentioning this as the most important household income source. Most of these labor activities were informal, as formal sector jobs were scarce in the study area. Sale of basic food crops was cited as the most important source of household income in only10% of intervention households, and 8% of control households.

The most important staple foods in this area (in terms of total quantities produced) were manioc, rice, sweetpotato, and maize. At Baseline, 60% of households were producing white-fleshed sweetpotato, with no significant differences between intervention and control households. Few study households produced sorghum, and none grew millet. Sugar cane was the most important cash crop for a third of study households as it is the dominant ingredient in locally produced alcohol. For slightly over 30% of households, cashew nut was the dominant cash crop. Coconut was the third most important cash crop, being the most significant source of cash in almost a quarter of study households.

Household production in general could be described as semi-subsistence, with the majority of households cultivating 2-3 fields mostly with family labor. Approximately 10% of households hired casual labor in 2002, with less than 1% utilizing permanent hired laborers. Most families possessed 2-3 hoes and had a slasher, but less than half possessed a bucket or an axe and only a few individuals had watering cans, sprayers, or shovels. Livestock holdings are extremely limited. Only one family owned a cow, 5% at least one goat, 4% at least one pig, and only one raised sheep. Sixty-eight percent of households had at least one chicken, but only a fifth owned more than five chickens.

The majority of families in the study area possessed few assets of moderate value, whether in intervention or control areas. The most commonly possessed item was small petrol lamps, with half of households owning one, and slightly over a quarter owning more than one. Close to a third of households had functioning radios, and a little over a third possessed bicycles. Control households were slightly more likely to possess radios and bicycles than intervention households.

Housing and sanitation conditions were poor in both intervention and control areas. Only 3% of households had latrines. Eighty-nine percent of the main sleeping dwellings have walls consisted of sticks plastered with mud. Eighty-two percent of houses had roofs of grass thatch; an additional 16% of leaves from palm trees. Eighty-three percent of dwellings had no windows, and only 5% had at least one window filled with glass or with a wood shutter. Only 1% of dwellings had cement floors, the rest were packed earth. Half of the main sleeping dwellings were found to be in poor condition and only 3% in good condition.

The dominant source of drinking water (75%) was unimproved wells in both rainy and dry seasons. Approximately a fifth depended on improved wells. Control areas had slightly better access to improved wells than intervention areas.

Thus, the picture emerging at Baseline was one of an extremely challenging agro-ecological, sanitary and social setting. Soils are poor, and rains undependable, forcing dependence on drought-resistant cassava as the key basic staple. Households were extremely poor as reflected in quality of housing, low possession of livestock and other assets, reliance on unimproved wells for water, lack of latrines and a non-diversified diet. Few significant differences existed in key characteristics of the reference children, women, and men between control and intervention areas, with the exceptions of control households having higher levels of participation in salaried employment than intervention households and control children being significantly more likely to be wasted than intervention children. The high level child malnutrition presented a pressing need for interventions capable of improving nutritional status that poor households in a poor resource environment could successfully adopt. Low education levels, particularly among women, influenced the type and complexity of interventions which could be employed.

2. DESIGN, SITE SELECTION, SUBJECTS AND METHODS

2.1 Conceptual Framework and Implementation Partners

The impetus for this project arose from a pilot study that introduced orange-fleshed sweetpotatoes among 20 women's groups in Western Kenya (Low et al. (1997), Hagenimana et al. (1999)). Results showed that selected varieties were acceptable to consumers and certain groups successfully developed and marketed sweetpotato-based processed products. The most important finding, however, was that increased frequency of consumption of vitamin A-rich foods by young children was higher in the intervention groups receiving nutrition education in addition to the new OFSP varieties, as opposed to the children of women in control groups, where only the agricultural component was introduced. This finding is consistent with other studies (Ruel and Levin, 2000, Berti et al., 2004).

The Kenya project did not target consumers outside of the intervention groups, beyond testing for the acceptability of several orange-fleshed sweetpotato (OFSP) processed products in local markets. Project participants were hesitant to expand the area under OFSP because of market uncertainties. Thus, the TSNI conceptual framework is broader than the one used in Kenya, adding market development to ensure sustained adoption and use of the new varieties.

The conceptual framework consists of three pathways, each of which may contribute to increases in young child intake of vitamin A and other nutrients (Figure 2.1):

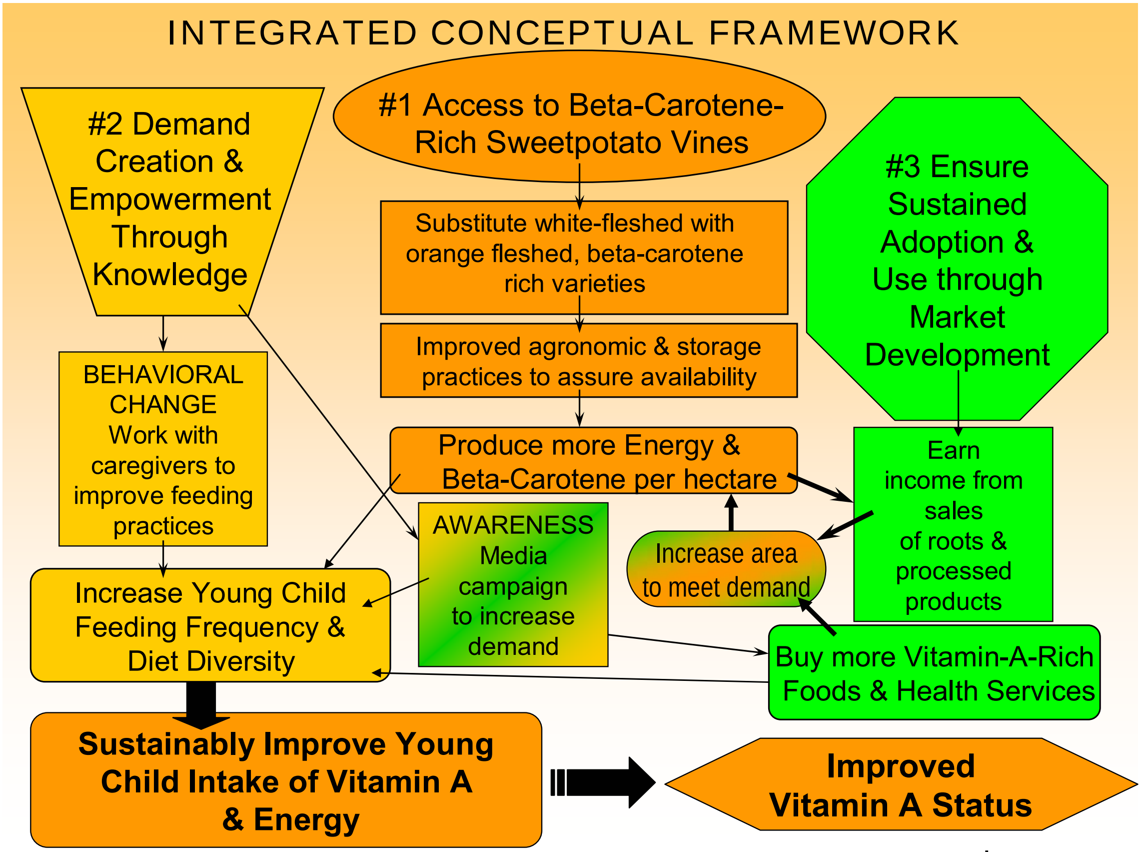
1) *Access to Improved OFSP Sweetpotato Vines.* Intervention farmers received (principally through groups) planting material of high-yielding beta-carotene-rich varieties and were directly involved in varietal evaluation. Rapid multiplication, staggered planting, improved agronomic practices and out-of-ground storage techniques were promoted to maximize the availability of orange-fleshed sweetpotato in both the adult and young child diet throughout the year.

2) *Demand Creation and Empowerment through Knowledge:* Levels of formal education achievement among adult rural women in Zambézia Province are extremely low. Health and knowledge surveys in many other parts of Mozambique have noted several major areas where caregiver awareness of good basic child feeding practices are severely lacking, including:

    a. Optimal duration of exclusive breast feeding
    b. Preparation of foods appropriate to meet the special nutritional needs of young children
    c. Frequency of feeding of young children in different age groups

    At the village level, nutrition extension agents sought to encourage and enable caregivers to improve infant and young child feeding practices, and to encourage diversification of the daily diet of the entire family.

FIGURE 2.1



At the community level, demand creation focused on creating awareness among the broader community for two reasons: 1) to create demand for the new cultivar and its derivatives, and 2) to create a supportive environment to accelerate behavior change at the household level. For example, if leaders of the community are aware of improved feeding practices and their importance, they could encourage residents to adopt the recommendations and even lead by example. Mass media (for example, radio) use assisted in reaching a broader audience.

3) *Ensure Sustained Adoption and Use through Market Development.* The demand creation component aimed to lead consumers to seek out OFSP in the market. Farmers knowing to whom or where they can sell their crop are more likely to expand area under production. The market development component aimed to link farmers to traders and informs consumers about where they could purchase OFSP. Thus, generated demand combined with market development would stimulate increased production, enhance producer income and spread the health benefits of OFSP to a wider population, all of which would contribute to farmers' willingness to retain OFSP in their farming systems and expand the area under OFSP production. Demand for OFSP would be enhanced if profitable processed products using OFSP as a major ingredient could be identified,

There are two principal mechanisms through which dietary diversification can be achieved at the household level. The first is **direct production** of crops containing significant quantities of the desired nutrient. The second is through **market purchase**. Given the poor quality of the soil in the target districts, sweetpotato is one of the few crops that can give acceptable yields without significant use of inorganic or organic fertilizers. Many of the other micronutrient rich foods will have to be purchased in the market. The framework hypothesizes that consumers aware of the value of vitamin A rich products to their health will desire to buy more vitamin A rich foods than those that are not.

Enhancing the purchasing power of caregivers in OFSP producing families through enabling increased OFSP commercialization improves their capacity to capitalize on whatever new knowledge they have obtained through market purchase of a more diversified diet.

In this framework, orange-fleshed sweetpotatoes were the **entry point** for improving caloric and vitamin A intake among young children. OFSP constitute an easy-to-produce, rich source of beta-carotene to the household, providing caregivers with a low cost alternative for improving young child vitamin A intake and feeding frequency. It was hypothesized that consumption of other vitamin A rich foods and fats to enhance vitamin A absorption would also increase significantly due to the impact of greater knowledge regarding which foods to produce and feed to young children, combined with greater capacity to buy vitamin A rich foods through the sale of fresh sweetpotatoes and processed sweetpotato-based products.

If the integrated approach could succeed in raising young child intake of vitamin A-rich foods, we sought to determine if that improved intake would translate into improved vitamin A status. A child that is ill or carrying a heavy parasitic load will not absorb ingested vitamin A as well as a healthy child. Moreover, combating illness uses up significant quantities of vitamin A. Therefore, we sought to explore whether improved consumption could ultimately impact vitamin A status in an extremely challenging agro-ecological setting in rural Mozambique.

The project drew on five principal partners to implement this conceptual framework. Michigan State University led the design of research and training components, and oversaw overall project management and supervision of the nutrition extension activities. The National Agronomic Research Institute (INIA) in collaboration with the Southern African Roots Crops Research Network (SARRNET) provided new orange-fleshed sweetpotato varietal material, assisted in training extension staff, and coordinated regional varietal trials. World Vision directed the agricultural extension program and provided infrastructural support. The Nutrition Division of the Ministry of Health developed nutrition education materials appropriate for community level interventions and assisted in organizing stakeholder seminars and coordinating project activities with provincial, district, and local health personnel. Helen Keller International was responsible for developing the social marketing strategy to increase demand for vitamin A rich foods and promote behavioral change regarding care giving practices within the project areas.

All tables for the remaining sections of this report are provided in Annex A.

2.2 Site Selection and Sampling

Given the limited time available for the study, it was critical to work in an area where sweetpotato cultivation is widely practiced, child malnutrition levels are high enough to ease detection of significant changes in serum retinol, and extension partners have been established. Zambézia Province is home to 20% of Mozambique's population and among the country's 10 provinces has the largest number of households producing sweetpotato of any type (297,000 in 2002) (Departamento de Estatística, 2003) Rates of stunting are high – 47.3% of children under five years of age -- and the under five mortality rate is 212 per 1000 live births (INS, 2005). A national prevalence survey in 2002 found 68.8% of children 6-59 months of age vitamin A deficient (<0.7 µmol/L), and Zambézia is not likely to be better off than other provinces (Departamento de Saúde de Comunidade, 2003).

Three districts were purposefully selected for the study based on five criteria: 1) Among selected districts where the extension implementation partner (World Vision) was operating, 2) High levels of child malnutrition were present, 3) A common dominant local language was used, 4) Were outside of major flood plains and 5) Were logistically feasible, i.e., reasonable distances between sites. Within each district, villages were randomly selected proportional to population from within two pre-determined sub-groups: those within 10 kms of access to basic services and those beyond 10 kms to assure a thorough understanding of factors contributing to adoption of OFSP and modified practices.

A complete listing of all households was made for each proposed village in November through December 2002 with enumerators visiting each household to record total household size, the number of children less than 28 months of age (so that by the end of the study all children would still be under five years of age), resident in the household and whether that household produced sweetpotato. Table 2.1 summarizes by area and district the results from the 5,757 households listed. Thirty-eight percent of potential intervention households and 64% of potential control households (i.e. those with children in the appropriate age range) agreed to participate in the study. The lower rate of participation in the intervention areas is most likely due to the requirement that intervention households participate as members of farmers' groups receiving extension services. Thus, self-selection bias exists. However, given the subsequent similarity of key characteristics between study participants from the two areas at Baseline (Low and Tschirley, 2003) and the homogeneity of conditions faced by households within a given village, this bias is not considered to have significantly influenced the results.

Intervention villages were selected prior to control villages so that the latter could be matched as closely as possible in terms of agro-ecological conditions. Agreement was reached with government agricultural services and other organizations working in the area not to distribute OFSP during the study period. Control households, however, were potentially exposed to educational and promotional messages the project broadcasted via provincial radio. In the last year of the study, 27 of the 243 control households did obtain OFSP vines through informal channels.

2.3 Human Ethical Treatment Statement

The study protocol was reviewed and approved by the ethics review committees of its major donor, the Micronutrient Initiative of Canada, the University Committee on Research Involving Human Subjects of Michigan State University of the United States of America and the National Bioethics Committee for Health of Mozambique. A declaration of consent was prepared and read to each study household in the dominant language (Chuabo) and signed by both the principal woman and man (when resident) in the household before commencing the Baseline survey. There were no exclusion criteria at Baseline. Seriously wasted children (below -3 weight-for-height Z-scores) and children with hemoglobin levels below 7 g/dl were referred to appropriate health facilities for treatment and remained part of the study. All study children received 3 vitamin A capsules during the 24 months of intervention (at Rounds 1, 2, and 4).

2.4 Description of the Intervention and Data Collection Methods

Each intervention district had 2 male agricultural extension agents and 2 female nutrition extension agents resident in centrally-located villages for their work radius. Fifty-three farmer groups were formed and included both study families and others without young children not enrolled in the study. Both men and women were encouraged to attend group sessions held by agricultural and nutrition extension agents. However, in general, more men than women attend the agriculture sessions and more women than men attended the nutrition sessions. This could have been due to perceived gender division of responsibilities within the household and/or to attendees feeling more comfortable with an agent of their own gender. Occasionally the two agents would "swap" sessions to reach the other audience. Agricultural extension agents focused on OFSP production and commercialization for 24 months and introduced sweetpotato storage techniques and groundnut production in the second year of the intervention. Nutrition extensionists covered 12 nutrition and health topics over a 13-month period using various techniques including demonstrations, lectures with visual aids, songs, games and role playing. In half of the intervention households, six additional home visits were made approximately every two months. The broader behavioral change campaign included six radio programs broadcast for seven months in year 2, community theater on breastfeeding, complementary feeding and OFSP commercialization, decorated hats and *capulanas* (pieces of cloth worn as skirts) used as prizes, and promotional marketing booths for OFSP and other vitamin A rich foods in the largest local markets. Details concerning the behavior change communication strategy and extension activities are provided in the first-year Technical Report (Low and Tschirley, 2003). This report and all survey instruments employed during the study are available on the Michigan State University WEBSITE: www.aec.msu.edu/agecon/fs2/index.htm under Mozambique Sustainable Nutrition.

Agricultural Data

The agricultural extension agent recorded quantities of vines of each type of OFSP distributed and annually measured the area actually planted to OFSP by each farmer group member. Structured survey instruments were used to obtain annual estimates of production and sale of orange-fleshed and other sweetpotato and dominant staple food crops (manioc, maize and rice) and agronomic practices concerning OFSP and other sweetpotato production. Data were collected on whether the household was involved in production and sale of all major food crops and types of livestock.

Nutritional Knowledge Data

Nutritional knowledge was assessed at Baseline and at the last survey round using a structured survey instrument consisting of questions concerning the function of vitamin A, the identification of foods rich in vitamin A, good breast feeding practices, the desired frequency of feeding of young children at different ages and the causes of malnutrition. These questions were representative of different topics included in the extension messages. The principal male and female caregivers of the reference child were interviewed.

Food Expenditure Data

Food expenditure data were collected concurrent with the collection of the 24-hour recall data between August and October of 2003 and 2004. Because of the time-consuming nature of this interview, it was conducted only in a randomly selected sub-sample of study households. Twenty-eight percent of the final study sample (135 intervention and 76 control households) completed both rounds. A comprehensive list was made of food items available in the community and the person most responsible for food purchases in the household was interviewed. For each item on the list, interviewees were asked whether they purchased, produced, or obtained the item in any other manner (for example, gifts or hunting) during the main harvest season beginning around mid-April until the data of the interview. Items were divided between those likely to be purchased frequently (salt, sugar, etc) for which a one month recall period was used and those likely to be purchased less frequently, for which recall period was the entire harvest season. For any purchased item, the frequency of purchase, amount spent, and amount bought was obtained. For non-purchased items, the frequency and amount used was determined.

Dietary Data

Detailed 24-hour recall of the previous days consumption, using volumetric estimates of quantities consumed, were collected in the first post-harvest season in 2003 and a year later, at the end of the intervention, during the 2004 post-harvest season. Enumerators were carefully trained in volumetric measure techniques. For ingredients such as rice and flour, they would ask the preparer of the food to use the rice carried by the enumerator to each interview to physically show how much she used of a given ingredient, preferably using the container or other method (handfuls) that she actually employed. Then the enumerator would transfer the amount indicated by the interviewee into the appropriately sized measuring cup, demarcated to estimate the volume used. In the case of vegetables such as tomatoes, enumerators carried small, medium and large-sized wooden models and asked the interviewee to specify the size and quantities of each model used. Conversion tables were prepared to convert milliliters or standard models into grams. In addition to estimating the amount of ingredient used to prepare the dish, the enumerators estimated the total volume of the prepared dish and the total volume leftover to facilitate estimation of the total amount actually consumed by the household. After estimating the amount of ingredient used at the household level, the preparer was asked to demonstrate the amount of each prepared dish or ingredient consumed by the reference child.

Morbidity Recall Data

Morbidity data were collected approximately every six months. Morbidity recall data obtained from the principal caregiver focused on symptoms experienced by the reference child during the two weeks prior to the interview with detailed questions concerning the duration and gravity of diarrhea, acute respiratory infections and fever; if and where treatment was sought; and the occurrence and type of any serious illness since the last round of interviews.

Blood Sample Collection

Serum retinol was measured using the dried blood spot (DBS) method. Serum retinol as determined by DBS is highly correlated with values determined from venous blood samples (Craft et al. (2000), Erhardt (2005), Klemm (2005)). Because it requires only a small amount of blood from a finger prick, the community judged it equivalent to a malaria test and its collection was culturally acceptable.

Three nurses and one nutritionist seconded by Provincial Directorate of Health for the duration of the project were trained for two weeks in DBS collection by a researcher and a technician from the National Institute of Health of Mozambique, both of whom had used this method during the National Survey on Vitamin A Deficiency, Anemia and Malaria Prevalence among Children 6-59 months of age and their Respective Mothers in 2001.

In developing countries such as Mozambique where children are not receiving adequate sources of vitamin A in the diet and suffer from high levels of morbidity, recommended practice is to distribute vitamin A capsules every six months. The study protocol was designed to test the success of the food-based intervention in *maintaining* adequate serum retinol status in young children who were given vitamin A capsules at the outset of the study.

Serum retinol was measured 4 times at 5.5-6.5 month intervals for all intervention children and 3 times (Baseline (Round 1), Round 2 and Round 4) for all control children (Refer to Figure 1.2). Because both chronic and acute infections can depress serum retinol independently of dietary deficiencies, it is necessary to account for the influence of infection when using serum retinol to assess vitamin A status. Therefore, in addition to serum retinol, two acute phase proteins were measured. These two proteins function as markers for infection. C-reactive protein (CRP) was measured at rounds 1, 2 and 4, and α_1-acid glycoprotein (AGP) was measured only in Round 4. Levels of serum retinol, CRP and AGP from the dried blood spots (DBS) were determined by Craft Laboratories in North Carolina, USA. According to Craft et al. (2000), levels of serum retinol are determined using High Performance Liquid Chromatography (HPLC) and original retinol readings are adjusted to account for the non-uniform serum concentrations in the DBS sample used for analysis. Protocols for collection, storage and air shipment as recommended by Craft Laboratories were carefully implemented.

Collection of DBS samples was as follows:

1. At Baseline (May-June 2003), the DBS sample was collected for intervention and control children and all children then received a vitamin A capsule. This collection corresponded to the period when farmers' groups had received vines of OFSP to multiply and produce in group-level plots. Distribution of vines to individual households started in May 2003.

2. At Round 2 (Nov 2003-Jan 2004), the DBS sample was collected in intervention and control children, all children received a vitamin A capsule post-collection. Capsule distribution was contrary to the original design, which called for a placebo to be given to intervention children. This was due to two factors: 1) lower production of OFSP in participating households than expected due to poor rainfall during the second season of 2003 and 2) an outbreak of measles throughout Zambézia Province beginning in September 2003.

3. At Round 3 (May-June 2004), the DBS sample was only collected for intervention children, who subsequently received a placebo capsule. Control areas were not visited for Round 3. Control households had access to vitamin A capsules at health facilities as government policy included vitamin A capsule distribution as part of routine services[4]. Project personnel collaborated closely with health facilities in intervention areas during the whole study to prevent vitamin A capsule distribution to intervention children[5]. Only 3 intervention children received a vitamin A capsule through a health facility between Round 2 and Round 4. Five additional intervention children received a vitamin A capsule when Round 3 results indicated very low serum retinol status, as

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[4] The first nationwide distribution of vitamin A capsules in Mozambique occurred in 1999, linked to the last year of the National Immunization Days for polio. Subsequent nationwide distributions took place during Mother and Child Health Care Campaigns in 2000 and 2001. The Ministry of Health decided in 2002 to distribute vitamin A capsules as part of their routine Well Baby Consultations, which include growth monitoring and vaccinations. Coverage rates dropped in 2002 and 2003 to 51% and 44%, respectively, of all children under five. A study was initiated to investigate the problem and suggest alternatives for reaching all children under five, the results of which are expected by mid-2005 (HKI, personal communication).

[5] Project personnel visited every health facility in the study area to explain the objectives of the work, and to ask cooperation from clinic personnel during implementation. Since study households were receiving capsules through project personnel, two methods were used to assure that health facility personnel did not provide an additional capsule; this was to protect the children from receiving excessive dosages. First, a bright orange card was attached to the inside of the health card of each study child on which the date and location of capsule administration was recorded. Second, during the first two rounds, lists of all study participants were posted on clinic walls as references for clinic personnel to identify mothers and children participating in the study. Health facilities in intervention areas were again re-visited and missing or damaged lists replaced prior to round 3. Control area health facilities were informed that capsules could be administered to study children appearing in their facilities if the appropriate time period had elapsed since the last capsule.

stipulated in the ethics protocol for the study. Although first season production of OFSP was low, again due to drought, by May 2004 it was clear that normal yields of OFSP could be expected for most households during the second season of 2004.

4. At Round 4 (Nov 2004-Jan 2005), the DBS sample was collected in intervention and control children, and then, all children received a vitamin A capsule.

Thus, in this study, all children received 2 vitamin A capsules in year 1, followed by a 12 month period in year 2 in which we are assessing the ability of intervention package (the promotion of OFSP and the changes in behavior regarding child feeding) to better maintain serum retinol status compared to children in the control areas.

In addition to examining changes in mean and median plasma retinol concentration, two common cut-off points are used at a population level to identify the prevalence of vitamin A deficiency at different points in time and between intervention and control children: less than 0.7 µmol/L as deficient status and less than 0.35 µmol/L as severely deficient status. Vitamin A deficiency is considered to be of public health importance if at least 15% of a defined population has plasma retinol concentrations under 0.7 µmol/L or 5% has plasma retinol concentrations under 0.35 µmol/L (Sommer and Davidson, 2002).

Hemoglobin was collected from reference children and their principal female caregiver at Baseline and Round 4 due to anemia being a potential consequence of vitamin A deficiency. Blood hemoglobin concentration was measured in capillary blood using the HemaCue^{TM} portable hemoglobinometer, applying quality assurance procedures in a manual provided by Helen Keller International. Children and women with hematocrits below 7 g/dl (the cut-off point used by the Mozambican Ministry of Health) were provided with referrals to the nearest health facilities for follow-up treatment. The project assured that local health facilities had supplies of ferrous sulfate available to treat referred study participants.

Anthropometric Data

Senior project personnel provided extensive training to staff that would perform the anthropometric measurements. Weight, height or length and arm circumference of the reference child were taken by a trained measurer and his/her assistant, with additional assistance requested from the child's mother or father during any length measurement. Shorr Height-Length Measuring boards were used for length measurements of children less than 2 years of age, and for measuring height of children 2 years of age and older. Height was also obtained from all mothers, and any resident principal male. Length/height was measured twice to the nearest 0.1 cm, and could not differ by more than 0.5 cm. The Seca Model 881 Scales for Research were used to obtain digital readings of weight to the nearest 0.1 g for the selected study children and their mothers. With these scales, the mother of the child is measured first, and then the scale can be tarred to zero permitting the weight of the nude child to be accurately taken while being held in the mother's arms. Mid-upper arm circumference was measured in study children twice to the nearest 0.1 cm with a tape measure, on the left arm, with the arm in an extended position, mid-way between the elbow and the acromion. Both measures could not differ by more than 0.5 cm. Body mass index of adults was calculated as weight (kg)/height $(m)^2$. For children, calculated Z-scores for height-for-age and weight-for-height were based on the NCHS reference standards.

A major area of error in calculating accurate anthropometric indicators such as height and weight for age comes from inaccurate age data. To ensure the most accurate determination of age possible, each anthropometry team was provided with an age and sex specific table with the reference medians for weight, length and height, with accompanying columns showing ± 4 standard deviations. Any child whose height, length or weight was more than 4 standard deviations from the median was referred to the field supervisor who subsequently re-verified the age of the child. Age verification consisted of reviewing the health card, asking the mother and (if present) the father of the child to identify another member of the community who had a child born close to the same time as their child and reviewing that child's health card. In addition, the proposed birth date was matched to the agricultural calendar and key events over the past 5 years. Fifty cases were identified where age had to be re-verified.

2.5 Statistical Analysis

All non-anthropometric survey data were double-entered in CSPRO, versions 2.3-2.5, cleaned in SPSS versions 11.0 or 13.0, and analyzed in SPSS 13.0 or STATA 9.0. Data were examined for normal distribution using the Kolmogorov-Smirnov test of normality. With normally distributed data, independent sample t-tests or Scheffe's test were used to compare means between groups, and paired t-tests were used to compare the same groups in different rounds. For non-normally distributed data, non-parametric tests such as the Mann-Whitney test were used. Probability levels $(P)<0.05$ were regarded as significant in all tests unless otherwise indicated in the text.

Anthropometric data for all measurement rounds were linked, and cases where length/height or weight decreased across rounds were checked against the original forms. Z-scores for height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) were calculated in Epi Info (version 6.02), based on the NCHS reference standards. Values were flagged and cases examined for all z-scores exceeding limits defined by WHO (1995).

Differences in prevalence of in Z-scores for anthropometric data and purchases of different foodstuffs were assessed between relevant rounds using two-sided Chi-square tests. Within group changes in prevalence between relevant rounds were assessed using McNemar's tests. Finally, differences between changes in prevalence were compared between intervention and control areas using a Z-test based on the chi-square statistics from the McNemar's test. Differences were considered to be significant when p-values for tests were <.05.

3. AGRICULTURE AND MARKET DEVELOPMENT

3.1 Background

The research sites fall within the Low Altitude Region agro-ecological classification that consists of a strip of land under 200 meters in altitude bordered by the sea on the east and running inland between 50-150 kms in Zambézia Province. Depending on the topography, soils vary from sandy in the higher zones to heavy vertisols preferred for rice production in the lower areas (*zonas baixas*). Precipitation is variable, ranging from 500-1400 mm per year, with the heaviest precipitation occurring between the months of November and March, and the so-called second season from April through June. During the project period, significant drought was experienced in 2 of the 4 growing periods: the 2nd rains in 2003 virtually had no precipitation, followed by the 1st rains of 2004 which were erratic in timing and fell far short of expected averages in February and March.

The project built on three years of prior agronomic field trials conducted by partners SARRNET/INIA to test promising introduced beta-carotene-rich sweetpotato material throughout Mozambique. This work led to the official release of 9 orange-fleshed varieties, selected for having yields higher than local checks across a broad range of agro-ecologies, and being acceptable in taste and appearance to consumers.

Under normal rainfall conditions in Zambézia, sweetpotato can be planted twice per year in households with access to lowland areas with sufficient residual moisture during the dry season. To ensure supply in the diet year round, particularly in households lacking access to lowland sites, the project promoted drying orange-fleshed sweetpotato (OFSP) chips in the shade to reduce beta-carotene loss common in direct sunlight exposure. Fresh root storage in aerated pits was also demonstrated among farmers' groups in year two.

To develop a realistic market development strategy it was necessary to spend the first year monitoring prices of sweetpotato and of its market substitute cassava, and conducting a market channel survey that included assessing the profit margins of retail and wholesale sweetpotato sellers. A key challenge was to devise a system that encouraged households to produce surplus production, but at the same time assured sufficient home consumption, particularly in those localities where men had more decision making power over women concerning the selling of OFSP. The pilot concept tested in year two consisted of constructing a market booth decorated with promotional messages in a highly accessible location for both producers and purchasers of OFSP, enhancing the trading skills of a local small-scale trader, and contracting that trader to follow purchasing rules established by the project in exchange for exclusive use of the decorated booth and assistance by extension staff in establishing links with farmers' groups producing OFSP. The guiding principle underlying the strategy was to introduce the concept of quality grades, whereby 1st quality OFSP is purchased for a higher per unit price than 2nd quality OFSP, and OFSP not achieving 2nd quality status is never purchased, nor is white-fleshed local sweetpotato. This strategy seeks to create a new and exclusive market for OFSP based on its visible trait, while at the same time guaranteeing that a significant quantity of OFSP remains for home consumption.

The market development strategy also sought to increase the market for OFSP roots through introducing heretofore unknown processed products made with OFSP. Testing of four products concluded that "golden bread", in which 38% of wheat flour was replaced by boiled and mashed OFSP, had the highest probability of success. A pilot initiative was conducted with existing small-scale bakers in 3 rural markets.

3.2 Dissemination of Vines and Area Expansion

The establishment of multiplication sites for producing and distributing vines free of charge to project participants is described in Low and Tschirley, 2003. Due to limited quantities available in 2003, priority was given to households participating in the study. By 2004, adequate material was being multiplied by farmers' groups and project partners to ensure that all households belonging to farmers' groups in intervention areas received material.

The four project agricultural extension agents worked with 53 farmers' groups over the two-year period and monitored the amount of material distributed and area planted. In 2003, there were 323 men and 718 women participating in the groups. In spite of drought conditions during two of the four growing seasons, over 76% and 88% of farmer group participants receiving vines in 2003 and 2004, respectively, produced OFSP (Table 3.1). Farmers responded to production incentives in year two, increasing average plot sizes by approximately 10 times, from 33 to 359 square meters. Whereas no household produced at least 500 square meters of OFSP in 2003, 35% did in 2004. The presence of marketing opportunities helped induce this expansion. The pilot trader in Mopeia district recorded over 3.3 tons of purchases of OFSP from farmers in 2004.

When TSNI was designed, the common policy for sweetpotato vine distribution in Mozambique by SARRNET/INIA was to give planting material to farmers for free. Free material distribution by NGOs such as World Vision, however, has some unintended side effects. At the end of year one, agricultural extension agents reported that some farmers did not bother to protect and care for their vines after harvest with the expectation that the project would provide vines in the subsequent year. In the second year, extensionists emphasized techniques for preserving vines, and frequently reminded groups that the project would be ended in 2004, hence dependence on World Vision for subsequent free material would not be an option.

The majority of households, however, retain their vines during the driest parts of the year by planting in valley bottoms with sufficient residual moisture to sustain the vines, or leaving some roots in the ground to re-sprout when the next rain comes. The drawback to the latter approach is that farmers typically have a limited amount of material emerging when the first rains comes, that results in small plots of sweetpotato being produced. Households lacking sufficient planting material either must obtain cuttings from their neighbors or buy vines.

Economists typically classify vegetatively propagated crops like sweetpotato as a public good, because no private sector seed company would want to engage in the business of selling vines, because once farmers have them they do not need to return for further purchase, as is the case for hybrid maize seed. This model assumes, however, that farmers have access to appropriate land year round, and are able to maintain the quantity and quality of vines they need for the next season. A prolonged drought can severely reduce the quality of material, and the ability of different varieties to maintain vine vigor under water stress varies by variety.

In an effort to explore sustainable strategies for vine multiplication that did not rely on public sector or NGO dissemination efforts, in year two the project sold three treadle pumps to 2 individual sweetpotato vine producers and one group wanting to produce vines for sale. Only one of the three successfully completed the pilot experience, in part because he already was a serious producer of horticultural crops. In addition, to test whether demand exists for sweetpotato vine purchase, the project organized two pilot interventions. The first was to have a rural trader purchase vines from a farmers' group producing vines who re-sold them at the local market for 100% profit; the second was to sell vines at a subsidized price to a trader in the provincial capital who subsequently re-sold for whatever price he could obtain. The rural trader sold at least 500 kgs of vines at 3000 MT/kg (0.12 cents/kg) (approximately 60 cuttings), while the urban trader sold the 300 kgs provided to him at 8000 MT/kg (0.33 cents/kg). Vines sales are irregular, with high sales coinciding to days following heavy rains. Both traders preferred taking orders from potential customers and arranging to pickup/receive material from the vine producers on a given day.

Results indicate that considerable demand for sweetpotato planting material exists on a seasonal basis. Farmers are willing to pay for vines, but it remains to be seen whether profitable vine production enterprises can be established. Treadle pumps appear to be a viable technology when a permanent water source can be located close to the desired plot location.

3.3 Production and Yields of Sweetpotato Among Study Households

Detailed information on sweetpotato production of all types was collected among study participants for 2004 at the end of the study period. Ninety-four percent of intervention households cultivated any type of sweetpotato and 90% grew OFSP in 2004. In comparison, the figure for control areas hardly altered from Baseline, with only 56% of control households growing any type of sweetpotato in 2004. Twenty-seven (11%) of control households did grow OFSP in 2004, having obtained the vines from non-project sources.

Among all study households producing sweetpotato, 78% reported no significant loss of production after planting. Fourteen percent, however, had partial or total loss of production due to lack of rain. Five percent had losses due to insect or animal (moles, monkeys) attack.

Although sweetpotato is often classified as a "woman's" crop, participation by both genders in sweetpotato production was high in intervention areas. Among study households, 91% of intervention mothers and 88% of the principal men reported being actively involved in OFSP production in 2004. Those mothers not involved cited their own illness or caring for others as the principal reason.

Table 3.2 indicates that among those producing sweetpotato, median production of any type of sweetpotato was twice as high in intervention as in control households (127 and 63 kgs, respectively). Mean production was 64% greater in intervention than control households (187 kgs vs 114 kgs, respectively). OFSP constituted 68% of sweetpotato production in intervention households.

The majority of households did not drop white-flesh sweetpotato production, but produced both white- and orange-fleshed potatoes in 2004. Of the 120 households in intervention areas not producing *white*-fleshed sweetpotato in 2004, 77% (92 cases) had produced it previously. When asked why they were no longer growing the white-flesh sweetpotatoes, 38% cited the lack of vines, 13% insufficient time to plant more than one type, and 45% cited various reasons indicating that they preferred OFSP to white-fleshed sweetpotatoes including the presence of vitamin A, being more productive or tastier, and having a better market (Table 3.3). The lack of vines for white-flesh sweetpotatoes indicates susceptibility to drought on the part of some local varieties.

Overall estimates based on farmer recall of root output and extensionists area measurements indicate mean yields of 6.8 ± 6.4 tons/ha of sweetpotato on farmers fields in intervention areas in 2004 (Table 3.4). This estimate reflects the challenging environment in which the study operated, characterized by poor soils and insufficient rainfall. Among intervention households producing both OFSP and white-fleshed sweetpotato, 83% indicated that OFSP produced more per given area than the local white-fleshed sweetpotatoes (Table 3.5). That being the case, over time it would be expected that households would gradually reduce the area under white-fleshed sweetpotato in favor of OFSP if adequate amounts of planting material could be maintained and/or purchased by the household. However, crop cuts of both local white-flesh and OFSP varieties on farmers' fields made by extensionists during the second season of 2004 indicate that yields of OFSP are similar but not superior to yields of the most popular local white-fleshed varieties. Table 3.6 has yields of different OFSP varieties from 52 plots averaging 7.3 ± 3.6 tons/ha compared to 8.3 ± 2.9 tons/ha for white-fleshed varieties from 32 plots. Thus, substitution of white-fleshed sweetpotato with OFSP is likely to vary considerably between households depending on the localized performance of particular OFSP in a given area, consumer taste preferences, and specific market demand for given varieties.

3.4 Varietal Preference

Of the nine officially released OFSP varieties in Mozambique, five (Resisto, Cordner, Tainung 64, Kandee and Caromex) have a prostrate growth structure and distinctive leaf shapes and four (CN-1448-49, LO-323, Japon, Jonathan) have an erect growth structure and are difficult to distinguish without looking at the root itself. By the end of the first year (2003), five varieties emerged as most adapted to local conditions: Resisto, Jonathan, Japon, CN-1448-49 and LO-323 and were the varieties most utilized in the 2004 distribution program.

Among these varieties farmers exhibited a very strong preference for Resisto, with 64% of intervention households citing it as the preferred variety, followed by Jonathan at

6.5%. Seventeen percent of households, however, did not express any preference in most cases because they had only received one variety (Table 3.7). The overwhelming reason why Resisto is preferred is because of taste (Table 3.8). In addition, discussion with farmers' groups also revealed that the prostrate (spreading) growth structure of the plant is highly preferred to the erect structure of OFSP varieties such as Jonathan because it produces more roots per plant. Moreover, Resisto produces a higher percentage medium size roots (150-250 gms each) than the other OFSP varieties, a characteristic preferred by the market and consumers. Households prefer giving each family member a root to eat. Varieties such as CN-1448-49, which have a tendency to produce large, cracked roots, require cutting into pieces before cooking and/or serving.

While limited in scope, crop cut data also indicate that Resisto, Japon and CN-1448-49 are the highest yielding varieties among the introduced OFSPs that have adequate foliage production. Jonathan had much lower root yields, but high foliage output (Table 3.6) and in farmers' group discussions, farmers frequently rank Jonathan as being more drought resistant than Resisto. Ideally, one seeks a variety with high root yields, but that has sufficient vine production and vigor to enable the household to easily maintain vines over periods when rainfall is scarce. Under drought stress conditions, the most popular white-fleshed local varieties often appear to have more vigorous foliage than some of the introduced OFSP. However, results in Table 3.6 indicate that average foliage production is higher overall among OFSP than white-fleshed varieties (9.2 tons/ha vs 6.1 tons/ha, respectively). The relatively low foliage output of Cordner may in part explain why it has not spread as widely as the other OFSP varieties in the intervention areas. Clearly, further study is needed to assess the trade-off being vine and root production in drought-prone areas and to develop standardized indicators of vine vigor.

Varietal development is a continual process. TSNI collaborated with SARRNET/INIA by conducting adaptive research trials and taste tests on an additional 11 new OFSP varieties for three seasons in the two intervention districts. Four of the 11 new OFSP produced higher average yields than popular local varieties in the adaptive trials and should be considered for distribution in these areas (440215, Tib4, SPK004 and MgCl01).

3.5 Sweetpotato in the Food System

The relative importance of sweetpotato in the food system did not alter from Baseline. At the end of the study, cassava still was the dominant food crop, followed by rice, then by sweetpotato (Table 3.9). However, mean and median production of sweetpotato was higher than rice across all intervention households (Table 3.10), in part due to the poor main rains received in 2004, which is the only rice producing season, in part due to the promotion of increased sweetpotato cultivation.

Prices were monitored once a month in Quelimane, Namacurra Sede (district level market), Lualua, Malei and Mexixine in 2003, with the addition of Licuari Market in 2004. As can be seen in Figure 3.1 for the Quelimane market, compared to other major carbohydrate sources sweetpotato is one of the lowest in terms of price per kg. Fresh sweetpotato prices usually waiver around those for fresh cassava and maize grain and fresh cassava is its major substitute. Rice is clearly the most expensive staple carbohydrate on the market, followed by maize flour.

Table 3.11 presents prices for the major sources of vitamin A in the food system for 2003 and 2004, based on collected price data. On average, OFSP was the 2nd cheapest source of vitamin A in 2003 (60 meticais (MT), the local currency, equivalent to 0.25 cents, per 100 Retinol Activity Equivalent (RAE) units), and the cheapest in 2004 (34 MT (0.14 cents) per 100 RAE units). In 2004, meeting the recommended daily allowance for a child under 6 years of age with OFSP costs less than 1 cent. In 2003, only liver was a cheaper source of vitamin A due to its high retinol content (37 MT (0.15 cents) per 100 RAE units), but its price increased to 53 MT (0.22 cents) per 100 RAE units in 2004. Moreover, consumers must pay at least 6 times more for 100 gms of liver than for 100 gms of OFSP.

Thus, OFSP is a relatively inexpensive source of calories and a very cheap source of vitamin A in the Zambézian food system.

3.6 Commercialization of Sweetpotato and other Staple Foods by Study Households

Approximately one-fifth of all study households producing sweetpotato of any type at Baseline sold them. The conceptual framework envisaged market development as key to ensuring sustained adoption and accelerating area expansion. In low productivity areas characterized in this study, the primary concern of most households was their own food security. The main rains of 2004 were poor and thus, it is not surprising that levels of commercialization were low for all staple food crops among study households. Table 3.12 indicates that of the major staple foods, sweetpotato was the most commercialized, judging by the percentage of households selling the crop. Thirty-two percent of intervention households producing sweetpotato sold some in 2004, compared to 24% of control households.

In intervention areas, the mean amount sold by those selling sweetpotato was 54.9 kgs, of which on average 83% was OFSP (Table 3.13). On average, intervention sellers earned 75.5 contos (equivalent to 75,500 meticais, which is roughly $3.14 USD). By comparison, white-fleshed sweetpotato sales prevailed in control areas, with those who sold marketing on average 82.6 kgs for a mean value of 85.5 contos ($3.56 USD). The mean and median per kg price received by producers for selling pure OFSP are slightly higher than those for those of pure white-fleshed (Table 3.14). The median price for OFSP is 1.59 contos per kg, compared to 1.19 contos per kg for white-fleshed sweetpotato. Mean and median values earned by households selling other staple food crops are shown in Table 3.15. Figures indicate that average earnings per household by those selling rice are higher than for other crops (on average 326 contos or $13.48 USD), but staple food crop sales in general only provide limited cash inflows to study households.

Prices for OFSP were influenced in one of the intervention districts (Mopeia) by the presence of the pilot OFSP trader trained by the project. At his stall, the trader purchased first quality roots at 1500 MT per kg, and resold them at 3000 MT per kg. He purchased second quality roots at 1000 MT per kg and re-sold them for 1500 MT per kg. First quality roots had to be uncut roots, at least 200 gms each, with no evidence of weevil attack. Second quality roots were at least 100 gms, and a small amount of weevil attack and cut roots were accepted. Roots smaller than 100 gms or heavily damaged by pests or disease were not purchased. The purchase price was lowered when he bought at farm-gate to compensate for time and/or transport costs. From May through November 2004, the trader purchased 3.3 tons of OFSP, of which 64% were first quality roots. His gross margin was $188 USD.

The responsibility for deciding who sells sweetpotato is split fairly evenly along gender lines. Among study households selling sweetpotato in 2004 (189 cases), 42% of the time the decision to sell was made by a man, 43% of the time by a woman, and 14% the decision was made jointly. Significant differences exist between districts (Table 3.16) with men being significantly more involved in Mopeia than in Namacurra. Households selling sweetpotato in 2004 sold the greatest quantities to traders or agents assisting traders (47%), directly to clients in markets (35%), or to neighbors (16%).

3.7 Acceptance of Orange-fleshed Sweetpotato Among Consumers

Marketing promotion campaigns were designed to create awareness among consumers of the value of OFSP consumption, which in turn were expected to create market demand for the product. At the end of the study, a rapid assessment was conducted among consumers in two major markets: Lualua, where the sweetpotato promotional booth had been constructed, and in Licuari, where the only promotional activity done was golden bread. In total, 114 persons were approached randomly for interviews and of these, 25% had never bought OFSP. Forty-nine persons (43%) had bought OFSP and agreed to participate in the survey. Table 3.17 demonstrates that the survey participants represent a diverse group of consumers in terms of age distribution, level of formal education, and principal activity. Only 29% of the sample cited farming or fishing as their major activity, the rest represent traders, students and persons in salaried occupations that are likely to be net purchasers of food. A third of the interviewees were women and over half the sample had more than 4 years of primary education.

General knowledge concerning the value of OFSP is high. Answers to an open-ended query, “What do you know about OFSP?” (Table 3.18) reveal a strong association between OFSP and the knowledge that it gives health. Forty-one per cent of respondents even mentioned that it had vitamins. Almost half of the sample of consumers was also growing OFSP at home, but only 3 of the respondents were members of farmers’ groups served by the project. The head of the household was responsible for deciding to purchase OFSP in 80% of the cases. There was little ability to distinguish between varieties, as only 14% could provide the name of the variety they liked the most. In all cases the variety was Resisto (Table 3.18).

When OFSP was abundant in the market in 2004, 39% reported buying it two times per week, 35% more than two times per week, 18% less than two times per week, and 8% not at all (Table 3.19). When it was scarcer in the market only 16% purchased OFSP twice a week, and 45% did not purchase at all. Respondents were asked what their desired frequency of purchase would be if OFSP was available daily in the market. Eighty-eight per cent said they would purchase it 3 times or more per week during the hunger season, dropping to 35% during the peak harvest months of June and July when maize and rice are more readily available.

Table 3.20 reveals that to some extent the message of who really needs to eat OFSP has penetrated the market. To this open-ended question, over 40% of respondents mentioned women, small children, and school age children. Eighteen percent also mentioned men, and 4% the elderly. Almost half (47%) were not able to respond to the question.

Three-quarters of the consumers said they preferred OFSP to white-fleshed sweetpotato (Table 3.21). An additional 18% did not have a preference among the two. Most just cook sweetpotato without other ingredients in a little water, with the sample split between the practice of peeling or not peeling OFSP prior to cooking. Not peeling is recommended practice as more nutrients are retained. Other ingredients added to prepared sweetpotato dishes include coconut milk, beans and dark green leaves. Eighty percent of respondents reported *not* preparing OFSP differently for the child (Table 3.21). Of those that do, frying or adding coconut milk and mashing were cited as the way in which OFSP was prepared specially for the child.

Consumers have diverse and multiple sources from where they learned about vitamin A-rich foods (Table 3.22). Thirty-nine percent mentioned the radio as one of their sources and 45% mentioned a health center or hospital and 49% through contact with schools or school material. All respondents gave a health or a health-related response to the query regarding the importance of consuming vitamin A rich foods. Sixteen per cent specifically mentioned that vitamin A protects against disease. When asked to name three vitamin A-rich foods besides OFSP, 63% cited papaya, 49% dark green leaves, and 37% pumpkin and 12% mentioned carrots. Animal sources are much less well known. Only 6% mentioned eggs, 2% mentioned liver and 2% mentioned fish. The most common incorrectly cited sources were tomato (14%) and banana (12%).

The amount spent on OFSP per purchase ranges from 2 to 30 contos (Table 3.23), which would purchase approximately 1-15 kgs. Since the amount being purchased is relatively small, it is safe to assume that consumers are consuming their purchases within a few days after purchase.

Even though the sample size is small, these results indicated that OFSP is acceptable to a high percentage of consumers in these rural markets and that awareness that OFSP is good for your health and the source of vitamin A-rich plant foods has penetrated beyond households registered in the study. Demand exists for regular OFSP purchase, particularly in the hungry season.

3.8 Diversification of Use and Expansion of Availability through Processing

Fresh sweetpotato roots are widely available six months a year in the study area. There are three ways in which availability can be increased: 1) through staggered planting, utilizing valley bottoms with adequate residual moisture to enable at least two harvests per year, 2) storing sweetpotato in dried form, and 3) storing sweetpotato in fresh form. The project discussed all three options with farmers' groups and these groups selected appropriate strategies to test. Almost three-quarters of intervention households in 2004 planted sweetpotato in the lowlands as a means for preserving vines as well as producing additional roots. Of the two post-harvest storage techniques, slicing and drying sweetpotato chips was a practice existing in the area. Extension personnel advocated modifying the procedure--to dry the chips in the shade instead of in the sunlight--to protect beta-carotene content. The last technique, storing fresh sweetpotato roots was a new technology. The project tested a recommended practice among its own staff in year one, and then successfully demonstrated the improved pit storage technique with farmers' groups in year two.

Typically, sweetpotato roots are boiled or steamed and eaten whole. A few traditional dishes also exist in which sweetpotato is prepared in coconut milk as a type of stew. The project sought to increase the awareness of participants and their communities about diverse uses of OFSP as a means to increase frequency of consumption, as well as to increase the market for sweetpotato roots. At the household level, emphasis was placed on the preparation of enriched complementary foods for young children and the use of sweetpotato leaves as a vegetable. At the community level, the project explored the range of sweetpotato processed products that could be readily commercialized. "Golden" bread emerged as the most economically viable candidate for further investment. Table 3.24 compares the use of sweetpotato roots and leaves in 2004 by participants in the intervention and control areas. Slicing and drying chips was done by 39.4% of intervention households compared to 11.9% of control households. Three-quarters of intervention households who dried OFSP followed the recommendation to dry the OFSP chips in the shade. Only small amounts of roots were dried due to preference for fresh root consumption over dried chip consumption. The mean quantity of fresh sweetpotato dried by intervention households was 13.7 ± 17.2 kgs (fresh weight), of which 85% was OFSP. Control households dried a similar amount, 13.0 ± 13.7 kgs. Median values for both areas were the same, 6.3 kgs.

Annex B describes the project's field experiments and subsequent laboratory analysis by the Medical Research Council in South Africa to search for the simplest way for villagers to be able to dry sweetpotato chips and retain beta-carotene content. Contrary to expectations, the beta-carotene in the samples dried in direct sunlight was not completely destroyed. In fact, levels for dark orange-fleshed Resisto were only 21% lower, for an average of the two treatments in direct sunlight, than for the average of the four treatments not in direct sunlight. All dried chips, regardless of treatment or variety (dark or light orange), exceeded the minimum desired RAE level of 100 µg/100 gms. However, it is important to remember that further loss of beta-carotene is likely to occur during storage and during subsequent re-hydration into porridge. Thus, use for chipping of darker orange-fleshed varieties such as Resisto is superior to use of light orange-fleshed varieties like CN-1448-49.

Eighty percent of intervention households consumed sweetpotato leaves in 2004, compared to only 46.7% of control households (Table 3.24). The predominant leaf in the diet in all areas, as indicated by the consumption data, remains cassava leaves.

A major change in the percentage of households preparing sweetpotato-based complementary foods was seen in the intervention areas. At Baseline, only 6.4% of intervention households reported ever having made sweetpotato porridge. In 2004, 73.7% intervention households made sweetpotato porridge, while control households remained close to their Baseline level, with only 3% making sweetpotato porridge (Table 3.24).

In contrast, there was little use of sweetpotato flour, due in part to the project deciding not to promote its use as field observations indicated that flour would be more difficult to store at the village level than sliced and dried chips. Flour, unlike chips, is quite susceptible to insect attack. Nor was their much difference in the use of sweetpotato roots and leaves as an animal feed between the intervention and control areas. With the drought-prone conditions in Zambézia, a decision was made to focus on human not animal consumption given that surplus OFSP produced by farmers was easily sold in the market for human needs.

Finally, only 6% of intervention farmers stored sweetpotato as fresh roots in pits (Table 3.24). As stated previously, this activity was carried out at the group level in the last year of the pilot study, so larger-scale individual adoption would only be expected in subsequent years. Group trials indicated that the fresh roots without any insect damage selected for fresh storage could last 5-6 months with minimal losses when in protected pits equipped with a bamboo breathing tube for respiration.

At the community level, the project trained eight persons each in four localities on how to process four sweetpotato-based products: two requiring the use of wheat flour (golden bread and fried doughnuts) and two not requiring the use of wheat flour (juice and rolled fries). Subsequently, one to three persons trained in three of the four localities produced one or two of these products for sale during the 2004 OFSP season. Fried products were soon dropped due to the cost of oil. The product that emerged as economically viable is golden bread.

Bread is one of the first products made in rural markets when residents have access to wheat flour. The first round food expenditure survey conducted Aug - Oct 2003 among 28% of study households found that 63% had purchased bread in the previous month. Salt, sugar, cooking oil and biscuits were the other items purchased by over half of the households. Thus, bread "fortified" with vitamin A through the addition of OFSP is a potential vehicle for improving the vitamin A intake of the rural poor in Mozambique. The recipe for producing golden bread is provided in Annex C. The recipe adjusts the existing recipe that rural bakers use for bread, substituting 38% of the wheat flour with boiled and mashed sweetpotato and increases the amount of yeast to ensure bread rising. Table 3.25 compares the profit a Lualua baker made from producing pure wheat flour buns to a recipe where 5.7 kgs of fresh OFSP roots substituted for 6.3 kgs of wheat flour. Profit rose 92% for the baker primarily due to the lower cost of OFSP in relation to imported wheat flour and extending by one day the baker's use of a bag of purchased wheat flour (rural bakers must purchase an entire bag of flour in Quelimane). Other bakers paying a higher price for OFSP due to location still had profit increases of around 50%. Bread makers are constrained by the price they can charge. Purchasing power is extremely limited in Zambézia and buns over 1000 MT/bun are unlikely to be sold. Thus, golden bread succeeds in increasing profits through lowering total cost.

Two days of consumer taste tests comparing golden bread and pure white wheat flour bread were conducted in Licuari Market. Results from these tests displayed a strong preference for the golden bread over white wheat flour bread because of its heavier texture (fills the stomach) and its attractive golden appearance. Round golden bread buns were preferred over those with elongated shapes. Golden bread made from fresh boiled and mashed roots was preferred in terms of taste and appearance to golden bread made from re-hydrated dried OFSP chips. However, the use of dried OFSP chips may extend the period over which Golden Bread can be baked if the chips could be economically ground into flour prior to use as bakers disliked the laborious process required to mash the re-hydrated chips.

Samples from 5 different varieties of OFSP used to make golden bread from fresh, boiled and mashed roots and dried chips were analyzed by Paul van Jaarsveld of the Medical Research Council of South Africa. Two samples of each example were analyzed and results are shown in Table 3.26. Results indicate that three-quarters of the beta-carotene found in the bread samples is in the bio-available trans-beta-carotene form. As a rule of thumb, processed products with at least 15 µg/gm product of trans-beta-carotene can be considered good sources of vitamin A. Bread made from the fresh, boiled and mashed dark orange-fleshed sweetpotato varieties MGCL01 (Persistente), 440215 (Gabagaba) and Resisto meet this criteria as does bread made from dried chips of Resisto. Dried chips from MGCL01 and 440215 are slightly below the desired level. Bread made from the lighter orange-fleshed varieties (TIB 4 and Lo-323) contribute vitamin A to the diet, but fall short of having sufficient amounts of trans-beta-carotene to be recommended for making this product.

Since the vitamin A needs of individuals vary by age and sex, the contribution to vitamin A intake of small and medium golden bread buns made from Resisto or other dark orange-fleshed variety can be estimated using the dietary reference intakes as a guide. Because they are cheaper, small buns are purchased more often by school children and for children than medium-sized buns. For a child 1-3 years of age, a small bun of 60 gms would contribute 25% of daily vitamin A needs, whereas a medium-sized bun (110 gm) would provide 45% (Table 3.27). A medium size golden bread bun would provide 11-20% of an adult woman’s needs depending upon her reproductive status. A food product can be considered a good source of vitamin A if one serving provides 10% of the dietary reference intake amount (RDA) per serving and an excellent source if it provides 20%. In summary, small and medium-size buns made with darker orange-fleshed OFSP varieties are always excellent sources of vitamin A for children 1-3 yrs of age and good to excellent sources for other age-sex groups depending on the amount consumed and the requirements of the specific age sex group.

During the 2004 OFSP season, 150-200 buns of golden bread prepared daily four to five days per week were sold over a 4-month period (August-November) in 3 rural markets and irregularly from November 2005 onwards due to limited OFSP root supply. Bread makers reported that consumers readily bought the bread made within 1.5 days of baking. Bakers expressed interest in engaging in fresh root storage in protected pits in the future to reduce time spent in procuring roots.

A rapid assessment of consumers in the two markets where golden bread was regularly sold was conducted in February 2005. Of 112 consumers randomly approached, 58% had purchased golden bread. Table 3.28 confirms earlier taste test trial results that consumers like the golden color and the heavier texture of the golden bread compared to the white bread. Ninety-two percent preferred golden bread to white bread. Half of golden bread purchasers said that they would buy golden bread daily if it was available, although only a quarter of the sample currently purchases white bread daily (Table 3.29). Golden bread appears to satisfy consumer preferences in the area and the challenge remains to create a sustainable supply chain of OFSP roots for interested bakers.

In summary, results indicate that OFSP varieties were accepted to farmers, both men and women, in terms of taste and agronomic performance in a difficult agro-ecological setting. Households responded to market and production incentives by expanding the area under production in year two. Whereas there is a clear preference for consuming just boiled or steamed fresh roots, there was significant adoption of diversifying how sweetpotato is prepared, particularly for young children, and willingness to dry sliced chips for later consumption. Resisto emerged as the most popular of the nine introduced OFSP varieties, and has been shown to retain adequate beta-carotene content when sliced 2-3 mm thick and dried and when processed into bread. Awareness of the nutritional value of OFSP is widespread among consumers and market demand for OFSP exists with indications that a significant number of consumers are developing a distinct preference for OFSP over white-fleshed sweetpotato. The pilot experience with golden bread is promising given the potential for creating a market for surplus OFSP production and serving as a vehicle for improving vitamin A intake among rural bread consumers.

4. NUTRITIONAL KNOWLEDGE AND FOOD EXPENDITURES

4.1 Background

One of the key intervention pathways to improving child nutritional status is increased knowledge about the appropriate use of foods. Given the dominant role of principal men in the decision-making processes of households, it is important to assess knowledge of men as well as that of women, and subsequently assure that key messages reach all those who may influence a woman's care-giving decisions and resource base.

At Baseline, both principal men and mothers of the reference child were posed a series of questions to assess: 1) their awareness of vitamin A, 2) the depth of their knowledge concerning vitamin A rich foods, 3) their beliefs concerning certain aspects of breast feeding, 4) their ability to identify the causes of marasmus and kwashiorkor, and 5) their thoughts on the age of introduction and frequency of complimentary feeding. Women were posed additional questions on the content of weaning foods currently being fed to young children. In addition, information was sought from the principal men and women concerning who they turned to for advice on nutrition and health matters. Answers to these questions at Baseline helped the project to prioritize which gaps in knowledge needed to be addressed by the project and who were the most influential advisers on nutrition and health matters.

Baseline results were presented and discussed in detail in Low and Tschirley, 2003. At Baseline, the level of nutritional knowledge and appropriate child feeding practices was extremely low among women and men in the study areas. Lack of understanding about timing the introduction of liquids other than breast milk and complementary foods meant that infants were exposed to contaminated fluids at an early age, no doubt leading to increased illness, diarrhea in particular. Once complementary foods were introduced, however, they were not given in sufficient quantity and quality to assure good growth. On the positive side, the vast majority of children were breast fed on demand during their first year of life. Unfortunately, breast feeding could be abruptly terminated when the mother fell ill or became pregnant, due to incorrect beliefs concerning the qualities of breast milk.

At Baseline, the type of persons from whom advice is sought concerning dietary practices was quite similar among the principal caregivers of the reference child. Just over half of women and men reported seeking advice about dietary practices from their own mothers, around a quarter reported seeking advice from their mother-in-law and approximately one third reported they did not seek advice but relied on their own knowledge (Table 4.1). One's own spouse or health facilities were more often sources of advice for health problems than for dietary practices (Table 4.1). Therefore, to effect behavioral change in child feeding practices, consideration needed to be given to how to reach older women in the community as they were a strong influence on existing dietary practices.

4.2 Brief Description of Information, Education and Communication Intervention

Reviews of successful nutrition education programs in developing countries have emphasized some common themes. Integration of interpersonal and media channels (including traditional or "folk" media) is a common characteristic of many successful programs. Different channels influence different stages of the behavior change process (Cerqueira and Olson 1995, Zeitlin and Formacion 1981). In addition, development and testing of messages that respond to the needs of program participants ("receiver-oriented" messages) is another key feature of successful programs (Cerqueira and Olson 1995; Favin and Griffiths 1999). Trials of improved practices (TIPs) is one method to achieve this (Dickin et al. 1997) and was the method adopted by this project. TIPs constitute the core method in a consultative research approach that offers the potential to gain in-depth understanding of feeding practices, motivations and constraints to behavior change. Typically, several visits are made to caregivers in carefully selected households. Current nutritional practices are analyzed in the initial visits. During follow-up visits, the researcher negotiates some specific changes in feeding practices that the caregiver follows for a set period of time. Researchers subsequently learn from mothers which practices work. This process identifies effective and practical behavior changes that are acceptable and feasible for families.

As part of the capacity-strengthening component of the project, a Portuguese-speaking consultant who had applied the TIPS method in her own country, Brazil, was hired to train the project nutritionist and one provincial-level nutritionist in the design and implementation of the TIPS methodology. This consultancy took place for three weeks in July 2003. As part of that work, 12 key recommendations for promoting feasible changes in dietary practices were developed specifically for households receiving home visits (all reference children had attained 6 months of age when the messages were developed), summarized as follows:

1. Give OFSP to the child every day, preferably accompanied by a source of fat.
2. Provide one type of basic food such as rice, sweetpotato, manioc, maize, rhizome, sorghum, or millet, in each of the three principal meals: breakfast, lunch and dinner.
3. Give green leaves every day to your child.
4. Give fruit to your child at least once a day.
5. Put a teaspoon of fat in the meal of the child during the three principal meals.
6. Give at least one source of protein every day and if it is from plant source, complement that protein with a cereal.
7. Do not skip any of the three principal meals.
8. The child should eat from his/her own plate.
9. The mother should assist her child in eating.
10. The mother should stimulate the child to eat when he/she refuses.
11. The mother must pay lots of attention to her own personal hygiene and that of the child, especially when preparing food.
12. Give boiled water to the child. Take advantage of boiled water leftover after cooking certain foods like sweetpotatoes and manioc.

During the consultancy, test sessions and protocols for conducting recipe trials involving sweetpotato weaning foods were also developed. During project implementation, the entire community would be invited to participate in taste tests and demonstrations so as to create general awareness of OFSP and enriched weaning foods and create a positive environment for mothers to make changes in child feeding practices. In some areas, lack of sources of readily available local sources of fat and proteins restricted the ability of households to make enriched weaning foods on a regular basis.

Group sessions conducted by resident nutrition extensionists with each of 53 farmers' groups covered the following topics over a one-year period:

1. The signs, causes and consequences of malnutrition
2. Understanding that different foods serve different purposes and the need to eat a varied diet
3. Recipes for complimentary foods using OFSP as a base
4. Exclusive breastfeeding and why it is important
5. Complementary foods from six months to two years of age
6. Maintaining health during pregnancy
7. Discussion of how to enrich other complementary foods: example demonstrated with manioc as a base
8. Understanding disease transmission in the community due to poor hygiene and good hygiene practices to adopt
9. The value of growth monitoring and the consequences of sudden weaning
10. Women in the group teaching a few key messages to other women in the community

These sessions were reinforced during the second year by a community theater performance in each project village designed to attract all members of the community that the older women in the community were specifically encouraged to attend. Also, six radio programs were broadcasted during a six-month period.

Women not participating in the study were encouraged to attend group nutrition sessions, as were men. However, in practice, only a few men and older women regularly participated. Sessions on child feeding and care practices were often perceived by the community as an activity for mothers with young children and those without young children often explained that they needed to be working in their fields or doing other tasks. The exception to this is recipe demonstrations and community theater presentations where strong turnouts of participants occurred when communities had been adequately informed in advance.

4.3 Results of Comparison of Nutritional Knowledge

The remainder of this section focuses on comparing nutritional knowledge attained by the end of the study in intervention versus control households. Control households did have some exposure to some nutritional messages through six provincial radio programs promoting vitamin A rich foods. The change in level of knowledge between Baseline and Round 4 (the end of the study) is assessed using a simple index of selected indicators.

Principal Caregivers
At the beginning of the study, all 741 women evaluated for their nutritional knowledge were the biological mothers of the reference child. During the course of the study, 6 mothers died and an additional nine left. New caregivers took over with the exception of one household in which the child of the deceased mother was being looked after solely by its father. Since the women responsible for caring for these children participated in the nutrition sessions, they are retained in the final evaluation of nutritional knowledge.

For men, the study defined the "principal male" as a male resident in the household responsible for the welfare of the reference child. At the beginning of the survey, 81% of the study households had the biological father of the reference child resident. Eleven percent of households never had any principal male present. Because men who left may have been replaced by men who were not exposed to many of the nutrition messages, only the 394 principal men who were present at Baseline *and* at the end of the study (76.4% of study households) are included in the change in nutritional knowledge assessment (Table 4.2).

Assessment of Change in Nutritional Knowledge
The most basic knowledge to be gained during the project period was the ability to recognize the importance of vitamin A and know which foods were vitamin A rich. Awareness of the words "vitamin A" was high at Baseline due to prior communication campaigns linked to vitamin A capsule distribution; however, the role of vitamin A in maintaining health was little known. Table 4.3 presents responses to open-end queries concerning the importance of vitamin A. Whereas at Baseline only 12% of women in intervention areas mentioned vitamin A's role in protecting the body against disease, by Round 4 at the end of the study, 59% mentioned this fact, and 33% also mentioned that vitamin A protects the eyes. Awareness of vitamin A's role also increased among intervention men, but only small increases occurred among control women and men specifically mentioning its role in disease prevention and eye protection. Percentages of respondents being able to cite another true fact about vitamin A were much higher both among intervention and control men and women in Round 4 compared to Baseline. The most commonly cited fact in this instance is the knowledge that vitamin A is good for your health.

At Baseline, knowledge of vitamin A rich foods was assessed by enumerators reciting a list of foods and asking the respondent whether or not it was vitamin A-rich. Subsequent analysis revealed a significant bias for respondents to just answer yes to most items. Therefore, at the end of the study, principal women and men were asked to name three sources of vitamin A rich foods, and three sources of foods rich in fat. As shown in Figure 4.1, 66% of intervention women and 55% of intervention men could name three sources. The most common error encountered was to consider fruits like orange and banana as vitamin A rich, indicating the association of the yellow-orange spectrum of colors with the presence of vitamin A. In the control group, 39% of women and 35% of men could also name three sources rich in vitamin A. Whereas these figures are much lower than for the intervention area, it may reflect exposure to the radio communication campaign and to market promotion stalls in the provincial capital. Approximately three-quarters of both women and men in intervention areas were able to correctly name three good sources of fat, compared to around half of men and women in the control areas. In intervention areas, fat consumption concurrent with vitamin A intake was widely promoted to maximize absorption of the available vitamin A in the plant source.

Table 4.3 also includes a summary of responses to five questions concerning appropriate breastfeeding practices and three questions concerning complimentary feeding practices that were covered in the nutrition group sessions. On all questions there were significant increases in the percentage of intervention women responding correctly. Among intervention men, significant increases occurred for all questions, except one, where the percentage of crawling children eating three or more meals daily unexpectedly declined from 70.8% to 51.8% of male respondents at the end of the survey. Increases in knowledge were higher for women than for men in intervention areas. The opposite was true in control areas for all but two questions, with control men showing a greater increase in knowledge than control women.

To roughly quantify the change in nutritional knowledge over time, a simple index was created assigning 1 point for each correct answer to the twelve categories listed in Table 4.3. Figure 4.2 presents the means representing the nutritional knowledge of principal women and men at the beginning and end of the study. There was no significant difference in the knowledge index between intervention and control women at Baseline ($p = .315$) nor intervention and control men ($p = .293$). Clearly, intervention women at the end of the study have the highest mean (8.1%), which is almost twice that of women in control areas (4.3%), and over twice the value of their mean at Baseline (3.2%). Intervention men also have a significantly higher mean (6.3%) than control men (4.7%) at the end of the study, and their mean also almost doubled since Baseline (3.4%). Control women also significantly improved their knowledge by a small amount between Baseline (3.3%) and the end of the study (4.3%), as did control men. Again, this is most likely due to exposure to provincial radio campaigns.

4.4 Factors Determining Improvement in Nutritional Knowledge

To understand the factors contributing to the improvement in the nutritional knowledge scores among women in the intervention areas, a linear regression model was employed to investigate how various factors contributed to the dependent variable in the model, the change in the nutritional knowledge score between Baseline and the end of the study (Round 4). The model seeks to address when age, formal education levels, and other characteristics of the women and household are accounted for, did the women receiving home visits in addition to attending group sessions have significantly higher changes in nutritional knowledge than the women just attending group sessions? What role did the degree of participation in group sessions drive the change in the nutritional knowledge score?

Table 4.4 summarizes the means of the dependent and independent variables included in the model. The nutritional knowledge score, with a maximum possible value of 12, changed on average almost 5 points (4.92) between Baseline and Round 4. Fifty-one percent of the intervention women received home visits. On average, intervention women attended 7.8 group nutrition sessions (the maximum number of sessions possible to attend was 11 or 12 depending on the site). The remaining variables in Table 4.4 reflect the woman's status at Baseline (age, education, nutritional status) and the degree to which she may be exposed to knowledge learning opportunities (possession of radio, engaging in commercialization of crops, or other off-farm earning activities).

Results from the regression analysis are presented in Tables 4.5 and 4.6. The ability of the model to explain the change in nutritional knowledge index is significant, but limited in magnitude with an adjusted R^2 value of 0.266 (Table 4.5). Coefficients for only two of the independent variables were statistically significant (Table 4.6): the number of groups sessions attended (B = 0.30) and the Baseline nutritional knowledge score (B=-0.625). These results imply that for every additional session attended, all other factors being equal, the nutrition knowledge score would increase by 0.30. The higher the Baseline knowledge score was, the smaller the overall increase (in terms of change in number of points award) was. Receiving additional home visits made no significant contribution to changes in nutritional knowledge.

Clearly, attending the group sessions emerges as a very key factor enabling improvement in knowledge. Yet 18% of intervention women attended fewer than 6 sessions. During the last round, women who missed 2 or more sessions were asked to describe the two main reasons why (Table 4.7). Over half the women stated that it was because they were ill. Almost 30% responded that they were taking care of an ill person. Twenty-three percent mentioned being outside of the village, and 13% had not been informed about the meeting(s) taking place. The poor health environment is the dominant factor affecting women's ability to attend group sessions and improve their nutritional knowledge.

Understanding the process of behavioral change is a complex process. The project nutritionist, Nadia Osman, conducted her dissertation research with a sub-sample of participating women throughout the TSNI project to better understand how messages are truly understood, what is retained, attitudes toward new proposed behaviors, and constraints to adopting new behaviors. Her results (due in 2006) will elucidate how well the behavioral change communication strategy functioned and provide insights on how to better design future interventions.

4.5 Food Expenditures: Patterns and Amounts Spent

The conceptual framework (Figure 2.1) hypothesizes that greater awareness of the importance of vitamin A rich foods, combined with increased incomes from the sales of sweetpotato roots, will lead to purchase of more vitamin A rich foods in the market place, which in turn will contribute to increased vitamin A intake.

Results from food expenditure information collected in a sub-sample of study households (28% of the total) indicate that households did not significantly alter their purchase patterns in favor of vitamin A rich foods. Table 4.8 presents the percent of households purchasing various foods at least once during the main harvest season during the 1st year of the intervention (2003) compared to the second (2004). The most commonly purchased food items in all households across both years are salt, dried and fresh fish, dried prawns, coconuts, maize flour, cooking oil, and bread. Table 4.9 shows the equivalent for the more frequently bought items purchased during the month prior to the interview.

In general, when significant differences do exist between the percent of households purchasing a given food item between control and intervention areas, the percentage is higher for control areas. The exceptions to this are for game meat, field and cane rats, and pork, where a larger percentage of intervention households purchase these items than control households (Table 4.8). There was a significant decline in the percent of households purchasing dried pigeon peas, chicken, pork, tomatoes, bananas, oranges, and pineapples between years. The one item for which both areas saw a significant increase in percent of households that item is rice. The percent of intervention households purchasing rice significantly increased from 15.6% to 25.9%, and from 28.9% to 44.7% in control households (Table 4.8). This reflects the widespread failure of the rice crop in 2004, forcing households to turn to the market. The percent of control households purchasing cooking oil also increased significantly from 51.3% to 69.7% between 2003 and 2004 (Table 4.9), but no significant differences between the percentage of households purchasing oil existed between areas in either year.

The only vitamin A source that is bought by the vast majority of all households is fresh fish. In 2003, 89.1% of households purchased fresh fish and 91.5% purchased fresh fish in 2004. No significant differences were found in between intervention and control areas for percent purchasing fresh fish or any other vitamin A rich food in either year (Tables 4.8 and 4.9). The percent of households purchasing eggs and liver did not increase between years, and only 3.3% and 0.9% of households bought eggs and liver, respectively, in 2004. Percent of households purchasing pumpkin significantly declined from 14.2% in 2003 to 6.6% in 2004, and those buying papaya dropped significantly from 6.6% to 2.4%. Less than 5% of households purchased OFSP, carrots or condensed milk in either year.

Households did significantly increase their total mean and median monthly expenditures on food during the main harvest period between 2003 and 2004 (Table 4.10). Mean monthly expenditures increased from 254.9 contos (254900 meticais, approximately $10.6 USD)) in 2003 to 292.1 contos ($12.2 USD) in 2004, but there was no significant difference in the level of expenditures on food between intervention and control households.

Total mean expenditure on vitamin A rich foods during the main harvest season in intervention household did increased significantly between 2003 and 2004, from 46.0 to 54.4 contos ($1.9 to $2.3 USD) (Table 4.11). In contrast, amounts spent by control households did not increase between the years. However, no significant differences in mean monthly expenditures on vitamin A-rich foods were seen between intervention and control households in either year.

Intervention households find it easier to produce plant sources of vitamin A rich foods such as OFSP, papaya, cassava leaves, and pumpkin leaves than to purchase them. The percent of all households producing OFSP and papaya increased between 2003 and 2004 and control households increased their production of pumpkin (Table 4.12). More intervention than control households produce eggs, but the percent of households producing eggs did not increase among intervention households between 2003 and 2004 (Table 4.13). Neither purchase nor production of animal sources of vitamin A increased significantly between the two years.

Intervention households selling OFSP in year 2 were specifically queried on how they spent the funds earned from OFSP sales. Only 13% used the money earned to buy at least one vitamin A rich food. The main reason cited for not purchasing vitamin A rich foods is that they are perceived as being available “locally”, and therefore one does not need to purchase them. The most common purchases made with money from OFSP sales were dry fish, salt, clothing for children and women, soap, fresh fish, cooking oil and kerosene.

In these resource poor households, priorities for cash purchases are concentrated on food and non-food products essential for meeting basic needs that cannot be produced on-farm. Since some of the vitamin A rich foods can be produced on-farm, the perception appears to be that scarce cash resources do not have to be spent to buy different kinds of vitamin A rich foods than those that are produced within the household. The one vitamin A rich source that is frequently purchased, fresh fish, was already part of the existing food expenditure pattern. There was no significant increase in the percentage of intervention households purchasing fresh fish or the mean amount spent on fresh fish between 2003 and 2004. The significant increase in mean amount spent monthly on vitamin A rich foods by intervention households between 2003 and 2004, 8 contos, is likely to reflect overall price increases not intentional shifts in purchasing patterns.

5. CONSUMPTION

Succeeding in producing orange-fleshed sweetpotato (OFSP) does little good in solving the young child malnutrition problem if young children fail to consume OFSP in significant amounts. Four key questions are addressed in this section:

1. When OFSP is available, either at the household or market level, are there significant increases in energy and vitamin A intake at the household level?
2. Are significantly higher intakes of energy and vitamin A seen among intervention reference children compared to control children?
3. If improved vitamin A intake is seen among intervention children, what is the contribution of OFSP?
4. Are any differences seen in the level of consumption of energy and vitamin A between intervention children whose caregivers received home visits compared to those whose caregivers did not receive home visits?

Results shown in this chapter are based on the last round of consumption data (24-hour recall) and from the repeated food frequency questionnaire (both are described previously in the methodological section and were collected during the main sweetpotato harvest season). Household-level results from the 24-hour recall are presented first, followed by 24-hour recall results and selected food frequency results at the level of the reference child.

5.1 Household Nutrient Intake

Mean and median values for the major macro- and micro-nutrients consumed by the household are shown in Table 5.1. Also included in the table is the inhibitor phytate, a common element in cereal and legume crops, that negatively affects both zinc and iron absorption. The values are presented on an Adult Equivalent (AE) basis, in which the reference man of 18 to 30 years of age requires 2987 kcal/day. [7] Residents who were not at home during the day of measure, and whose consumption outside the household was not captured were excluded from the AE calculation. Visitors, however, were included.[8]

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[7] The reference weight data used to determine the adult equivalent units are based on values calculated for Mozambique (James and Schofield, 1994) which take into account the energy needed to maintain weight as well as the energy necessary for occupational and "socially desirable" activities. In developing countries such as Mozambique, occupational activities are assumed to require moderate to heavy energy expenditures. The recommended levels of energy intake used to derive the AE unit by age and sex are provided in Annex D.

[8] The presence of visitors was noted at each of the three main meals in four categories: males<14 years of age, males 14 and above, females<14 years of age and females 14 and above. For the energy conversion, each person under 14 years was assumed to be 7 years of age; each person 14 years of age and above was assumed to be 30 years of age. If the visitor was only present at one of the three main meals, his/her AE value was weighted by one-third.

Mean values are significantly influenced by extremes.[9] All nutrient and phytate intake values are non-normally distributed.[10] Thus, it is important to examine differences in the median values, which may more accurately reflect the “average” situation, and to test for significant differences in distribution of intake levels between intervention and control households using a non-parametric test statistic. In this section, the Mann-Whitney non-parametric test statistic is used to determine whether significant differences exist between the intervention and control household distributions.

Median intakes of the following nutrients were significantly higher among intervention as compared to control households ($p < .05$): energy, vitamin A, vitamin C, vitamin E, vitamin K, iron, zinc, calcium, magnesium, folate and the B vitamins except B12 (Table 5.2). No significant differences existed between median intakes of protein, lipid, retinol, selenium, phosphorus, vitamin B12 or phytate. Median household energy intake was 11.8% higher in intervention than in control areas. The difference in vitamin A intake is more dramatic: **median vitamin A intake at the household level in intervention areas is 7.1 times higher than in control areas**.[11] As there was no significant difference in retinol intake between the areas, this difference in vitamin A consumption is being driven by the much higher intake levels of beta-carotene in intervention areas. In Table 5.2, Recommended Dietary Allowances (RDAs)[12] values for an adult equivalent male are given to provide a point of reference for assessing levels of intake.[13]

Overall, one can conclude that the quality of the diet is significantly better in intervention than in control households, but that there is still significant need to increase intake of many essential nutrients even in intervention areas.

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[9] All extreme values were verified against the original data. In the case of energy, extreme values are driven in most cases by the probable over-estimation of cassava flour in a few households. In the case of proteins, fats and vitamin A, the extreme maximum values are possible, reflecting the high nutrient content of the particular item heavily consumed on the day in question.

[10] Shapiro-Wilk test ($p = 0.000$) for all nutrients and phytate rejects normality hypothesis.

[11] Beta-carotene is the precursor for vitamin A (retinol). For beta-carotene-rich sweetpotato a conversion rate of 12 parts beta-carotene to 1 part retinol was used. The nutrient composition table was principally derived from two sources: the United States Department of Agriculture nutrient composition table, (version 16) and the Food Composition Table for Foods Commonly Eaten in East Africa by West CE, Pepping F., Scholte, IT. et al. (1987) with vitamin A values adjusted to represent retinol activity equivalent (RAE) units. Density values used to convert volumetric measures or standard units into grams are provided in Annex E. The nutrient composition table for key nutrients are shown in Annex F.

[12] These values are from the dietary reference intakes (National Academy of Sciences, 2004) for individuals and consist of Recommended Daily Allowances (RDAs) and Adequate Intakes (AIs), both of which are used as goals for individual intakes. RDAs are set to meet the needs of 97-98% of individuals in an age-sex group. AIs are believed to cover the needs of individuals in the group, but lack of certainty in the data do not permit stating with confidence the percentage of individuals covered by this intake.

[13] RDAs are given for reference only; note that depending on the distribution of intakes, a substantial proportion of intakes can be inadequate even when median intakes are at or above the RDA. Intakes substantially below RDA suggest that many individual intakes may be inadequate. As noted in Section 2 (Design, etc.), only one 24-hour recall was taken for each round of consumption data. A single 24-hour recall can be used to determine group means/medians, but in order to assess the proportion of the population who are likely to have inadequate intakes, multiple recalls are necessary in order to characterize intra-individual variation and the true shape of the intake distribution. Multiple recalls were not possible due to financial constraints, given the large sample size. In subsequent regression analyses, community level means will be used.

Since improved energy and vitamin A intake were key goals of the project, it is important to examine which foods are driving these increased levels of intake. Table 5.3 demonstrates that the two most commonly used ingredients were cassava flour and tomatoes (excluding salt which was consumed by almost all households). Cassava flour was consumed by 86% of intervention households and 71% of control households. Approximately half the households in both areas consumed rice and around a quarter used maize flour. Consumption of sweetpotato contrasted sharply between areas. OFSP was consumed by 34% of intervention households, in contrast to 3% of control households. In contrast, a higher percentage of control households (28%) ate white-fleshed sweetpotato compared to intervention households (17%). Yellow-fleshed sweetpotato consumption is limited in both areas as the project is only promoting orange-fleshed material and few local varieties of yellow-fleshed material exist.

The dominant role of cassava as the key provider of energy in the household diet is reinforced in Table 5.4. When cassava flour was present in the diet, on average it contributed 47% of total daily energy consumption in intervention households, and 59% of calories in control households. Rice and maize were the second and third most important contributors to energy intake, each contributing at least a third of caloric intake when present in the diet. When either orange or white-fleshed sweetpotato were present in the diet, their contribution was similar across both areas, contributing on average 12-14% of calories. The most important source of fat comes from coconut and its major derivative, coconut milk. Over 50% of households used some form of coconut and when consumed, it contributes 9-12% of energy intake of the household diet.

The two dominant sources of vitamin A in the household diet were OFSP and papaya (Table 5.5). Papaya was consumed by almost half the households in intervention areas, compared to approximately a quarter of households in control areas (Table 5.3). The third most important source was fresh fish. Pumpkin and mango did not have the potential to be significant sources of vitamin A as they are not in season during the post-harvest period (August-October). **When OFSP was consumed in intervention areas, it contributed on average over 89% of the vitamin A ingested that day**. In contrast, on average papaya when consumed provided 57% of the vitamin A intake in intervention areas, and 80% in control areas.

One simple indicator of diet diversification at the household level is the number of ingredients used for preparing food during the last 24 hours. The mean number of ingredients used by intervention households was 7, a small but significant difference from the average of 6 ingredients used by control households (Table 5.6). Improving diet diversity to a greater extent is seriously constrained by the limited number of crops that can be grown in this difficult environment and by lack of purchasing power.

5.2 Reference Child Nutrient Intake

The nutrition messages promoted by the extensionists strongly emphasized the need to eat vitamin A rich foods on a daily basis, the importance of diversifying the diet and the need to increase the feeding frequency of young children. The potential contribution of OFSP to the young child diet was stressed; and, demonstrations were given of enriched complementary foods using OFSP as a key ingredient to encourage caregivers to combine locally available sources of fats and proteins with OFSP to make a nutrient-enriched porridge. At Baseline, only 5% of study women reported ever having made porridge using sweetpotato even though 69% of households produced sweetpotato. In 2004, 74% of intervention households made sweetpotato porridge, while only 3% made sweetpotato porridge in the control areas.

Just because OFSP is being consumed at the household level, does not mean that it is found in the young child's diet. Consequently, after obtaining data on quantities consumed at the household level, the study asked specifically about the level of consumption of the reference child. Reference children averaged 32 months of age at the time of the final consumption survey. Sixteen percent were 1-1.9 months of age, 82% were 2-3 years of age, and only seven children had reached 4 years of age. Fifty-four percent were girls, and 46% boys. There was no significant difference in the mean age or sex distribution between intervention and control reference children.

Levels of nutrient consumption for the reference child are shown in Table 5.7. Similar to the situation at the household level, these non-normally distributed intake values are best compared by evaluating differences in the overall distribution and relying more on medians than means. Intervention children had significantly higher average levels of intake for energy, vitamin A, beta-carotene, vitamin C, vitamin E, vitamin K, iron, magnesium, folate, thiamin, riboflavin, niacin and vitamin B6 (Table 5.8).[14]

Median energy intakes in the intervention areas exceeded control values by 14.2% (Table 5.8). Although no minimum standards exist for fat intake, levels of fat intake appear low in both areas. Fats are a dense source of energy and enhance the absorption of vitamin A (Sommer and West (1996),Takyi (1999)) Normally, one would expect 30-35% of calories in the young child's diet to come from fat (2005 USDA Dietary Guidelines for 2-3 year olds). But for study children, on average, only 11.1%[15] of calories came from fat.

The contrast in vitamin A intake between intervention and control children is similar to that seen at the household level**. Mean intake of vitamin A was 7.8 times higher in intervention than control children, and median intake 8.3 times higher.** Again, the intake of beta-carotene, not retinol, is driving the difference in overall vitamin A intake. Note that daily intakes of vitamin A can be highly variable and excess amounts of vitamin A consumed are stored in the liver for later use.

[14] Mann-Whitney U two-sample test ($p < 0.05$).
[15] Median value is 11.1%, mean value 12.4%. There is no significant difference between areas.

The RDAs shown for children 1-3 years of age in Table 5.8 are as a point of reference (see footnote 7). The nutrient content of 100 grams of a typical medium-intensity OFSP variety is also provided for reference. Given that the RDA for children 1-3 years of age is 300 µg (mcg in tables) retinol activity equivalents (RAEs) and 400 µg RAEs for children 4-6 years of age, 100 grams of medium or darker intensity OFSP could easily provide the RDA. However, with the loss of vitamin A in processing, poor absorption and illness, intake above recommended levels is highly desirable in an environment such as rural Mozambique. The median value for vitamin A intake for control children is extremely low at 56 µg compared to 468 µg for intervention children.

Median values for both intervention and control children far exceeded the basic recommended intake levels for protein (13 gms per day), largely due to the presence of dried and fresh fish in the diet.

One of the major reasons that intervention children were attaining higher caloric intake than their control counterparts was due to a **significantly higher percentage of individuals in intervention households eating three major meals a day** (Table 5.9). Increased frequency of feeding of young children and not skipping major meals were key nutrition messages promoted by the extensionists. Seventy-five percent of intervention household members ate three meals a day compared to 62% of control households. This is because intervention households are more likely to take a meal in the morning than control households.

In particular, intervention children and adults 25-50 years of age were much more likely to eat three meals a day than their equivalents in control areas (Figure 5.1). Future analysis will discern whether this difference in intake is principally due to differences between the resource base of the households or a function of an education effect. Whatever the cause, the additional meal(s) are additional opportunities to acquire nutrients, and no doubt contribute to higher average caloric intake in intervention areas. For example, 80% of 2-3 year olds ate three meals a day in intervention areas compared to 60% in control areas. Moreover, a dramatic difference between study areas is seen in children 6-11 months of age, most of whom were born during the study period. Forty-nine percent of children 6-11 months of age in intervention areas were eating three meals a day, compared to only 17% of control children in the same age bracket.

Diet diversity was also higher among intervention than control children. A simple additive index was constructed, that was based on whether or not the child ate at least 10 grams of a given food group (except for fats/oils where the cut-off point selected was 5 grams of consumption), with the index ranging from 1 (only one food group consumed) to 9 (all food groups consumed).[16]

[16] Food groups are created based on common characteristics shared by the product. Classifying sweetpotatoes is a problem. White-flesh sweetpotatoes would typically be classified as either a source of carbohydrate, or as a vegetable. However, unlike other vegetables, sweetpotatoes have significant carbohydrate content. An argument can be made that beta-carotene-rich staple foods have both calories and vitamin-A, and hence, warrant the creation of their own food group.

Table 5.10 shows the percentage of children consuming the amount specified for each group, followed by the percentage of children consuming a minimum of 1 to the maximum of 7 food groups encountered. The mean number of food groups consumed by intervention children (4.0) was significantly higher than the mean number consumed by control children (3.4).[17] **Intervention children succeeded in having more diverse diets than control children, principally through higher consumption of foods from three groups: vitamin-A rich roots (i.e., the OFSP), vitamin A-rich fruits and vegetables, and legumes and nuts (principally groundnuts).**

5.3 Consumption of OFSP Across the Life of the Project

Repeated food frequency questionnaires provide a picture of changes in OFSP consumption by reference children across seasons and through the life of the project. Table 5.11 shows that at Baseline reference children ate very little OFSP in either the intervention or control areas. Frequency of consumption increased slightly in the control area across the life of the project, but the median number of days sweetpotato was eaten in the last week remained at zero in these areas throughout the life of the project. In contrast, the median number of days increased from zero to three in the intervention area, and during the last two rounds of food frequency data collection, slightly more than half of the reference children in the intervention area had eaten OFSP three or more days in the last seven.

5.4 Role of OFSP in the Young Child Diet

Sweetpotato is best known for its potential to contribute to vitamin A intake, with the amount of beta-carotene varying between varieties. Quite similar to the situation seen at the household level when OFSP was present in the diet, it was the principal source of vitamin A in the young child diet. Papaya and fresh fish, and to a lesser extent seafood and dark green leaves, were also important sources (Table 5.12).

If the entire sample of children is considered, including the two-thirds of children who did not consume OFSP on the day prior to the survey, OFSP contributes 31% of vitamin A intake to intervention children compared to 2.6% of intake in control children (Table 5.13). The mean daily amount consumed is 103.8 ± 174.8 gms in intervention areas contrasted with a mere 7.1 ± 45.8 gms in control areas. OFSP is also contributing over 10% of the nutrient intake of vitamins E, K, C, B2 and B6.

[17] Independent sample t-test ($p < 0.000$).

Between June and November 2004, reference children in intervention areas consumed OFSP on average 2.8 ± 2.7 times per week (median 2.0)[18]. The highest months of average consumption were in August and September. Given that all reference children had attained the age where they could eat "family food", special porridge preparation just for the reference child was rare. The last round of 24-hour recall data indicate that most of time the child received a portion of the food prepared for the entire family. In the intervention areas, the preferred time for serving OFSP was at breakfast, which was 62% of all times OFSP was served.

On the days sweetpotato was consumed in intervention areas, the young child ate an average of 300 gms of cooked OFSP, equivalent to 2 peeled, boiled and mashed, medium-sized sweetpotatoes. This level of consumption is consistent with field observations during home visits and demonstrations. The average RAE content of raw OFSP is valued at 727 in the nutrient composition table. Assuming a 30% loss of RAE during cooking, on average children one year of age and above are eating at least five times their RDA of 300 RAE at a single setting. It is plausible that some of this "excess" intake could translate into liver stores of vitamin A.

In the control areas, 82% of children did not consume any food source rich in vitamin A compared to 46% of intervention children. The conversion of beta-carotene into vitamin A is enhanced by the presence of fat at the same meal. In spite of promoting the addition of fat whenever possible to the young child meal, most families faced difficulty in doing so due to their limited resource base. The average amount of fat consumed in the same time period as OFSP was only 0.93 gms. Breast milk is high in fat, and would presumably contribute to the absorption of carotene, if consumed at more or less the same time. In the final round, only 9.6% (71 individual) reference children were still breastfeeding, since over 90% of the reference children were more than two years of age.

Table 5.14 summarizes the key results concerning child nutrient intake linked to the main objectives of the study. The project achieved its objective of increasing vitamin A intake among young children through the introduction and promotion of OFSP, but not exactly as designed. The promotional message emphasized trying to feed at least a small amount of OFSP every day. In practices, children over 1 year of age ate large amounts (300 gms on average) 2-3 times per week coincident with the normal consumption practices among adults in the study area. Given that vitamin A can be stored in the liver, this alternative pattern of adoption probably has few negative consequences.[19]

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[18] During the final survey round of serum retinol collection, caregivers of intervention children were asked to recall average frequency of consumption of OFSP by the reference child by month starting with November 2004, and working backwards through June 2005.

[19] Particularly because of the large quantities of OFSP eaten by some children, we assessed whether the overall impact on the diet was positive by comparing intake of all nutrients between children who ate OFSP and those that did not, using the 24-hour recall data. This comparison allows us to confirm that there was not a negative effect of OFSP if, for example, other nutritious foods were displaced. Children who consumed OFSP had higher intakes of vitamin A, as expected, and also had higher intakes of riboflavin and vitamins B6, C, E and K. Intake of lipids was lower but the difference was not large.

The project also achieved its objective of increasing energy intake among young children, which is most likely due to an increased number of meals per day. More intervention than control children are consuming breakfast, and OFSP is principally being consumed as a breakfast food probably due to ease of preparation and the traditional perception of sweetpotato as a bread substitute. OFSP contributed on average 6% of energy intake.

Orange-fleshed sweetpotato provide a rich source of vitamin A for both adults and children in a season when other sources of vitamin A rich foods are limited. It is also contributing energy, vitamins E, K, C, B2 and B6 in significant amounts. One secondary objective the project was not able to achieve, in spite of distributing groundnut seed during the second year of the intervention, was to demonstrate that fat intakes in intervention areas were significantly higher than those in control areas. The addition of a small amount of fat to each of the main meals was a key nutrition message. However, agro-climatic conditions restricted the amount of fat-rich crops non-coconut growing households could produce and limited purchasing power restricted purchase of fat-rich foods in the market. The result is that the average percentage of calories contributed by fat is only 12% in all study households, far below desired levels of 30-35% for young children.

5.5 Differences in Young Child Intake Between the Intervention Groups

As described earlier, households in the intervention areas were split into two sub-groups: 1) those only participating in group sessions with the nutrition extensionists (246 households) and 2) those participating in group sessions and receiving additional home visits from the nutrition extensionist (252 households).

Results comparing reference child nutrient intakes between these two intervention groups at the end of the study are shown in Table 5.15. No significant difference was found in the average intake levels of vitamin A between the two groups. However, for the three key macro-nutrients (energy, protein and lipids) and many other micronutrients (iron, zinc, selenium, phosphorus, magnesium, folate, thiamin, riboflavin, niacin and vitamin B6) average intake levels are significantly higher for households receiving home visits than for households exposed to information just through group sessions.

One plausible explanation for these differences is that the key messages promoting OFSP and other vitamin A rich food consumption in the household was simple to understand and relatively easy for households to adopt. Adopting the more difficult practices (for example, adding a small amount of fat into each main meal) may have required greater reinforcement and encouragement that more direct one-on-one contact provides. Future regression analyses and results from the forthcoming dissertation by the project nutritionist to understand the behavioral change process currently being will permit greater understanding of the factors underlying these results.

6. HEALTH AND NUTRITIONAL STATUS

6.1 Assessing Serum Retinol Status: Practical Considerations

In field studies, vitamin A status is often assessed by measuring plasma retinol. In addition to examining changes in mean and median plasma retinol concentration, two common cut-off points are used at a population level to identify the prevalence of vitamin A deficiency: values below 0.7 μmol/L indicate deficiency and values below 0.35 μmol/L indicate severe deficiency.[20] In healthy populations, serum retinol begins to fall when liver stores of vitamin A are depleted. In such populations, serum retinol cut-off points reflect vitamin A status. In populations where food intake of vitamin A is inadequate, infectious disease can cause vitamin A deficiency through anorexia, decreasing vitamin A absorption and increasing vitamin A excretion (Stephensen, 2001). The role of disease is difficult to assess, however, as the presence of inflammation caused by infection can impair the assessment of vitamin A status by *transiently* depressing serum retinol concentrations. Thus, in interpreting serum retinol outcomes, it is important to try and distinguish low plasma retinol due to infection, which is transient, from that due to dietary deficiency, which persists when infection ends.

Consistent patterns of inflammatory response are seen for a wide range of illnesses, and can last for several days or even weeks or months (the latter are referred to as chronic inflammation) (Tomkins, 2003). “The acute phase response is the body’s immediate reaction to infection and inflammation, and changes in the synthesis of acute phase proteins are to maintain body homeostasis and avert tissue damage” (Paracha, et al., 2000 p. 1164). Hence, the presence of the acute phase proteins (APP) “mark” the presence of illness and several APP can be used to help understand and control for the presence of infection. The most commonly used APP is C-reactive protein (CRP) which is useful for monitoring infection and inflammatory activity in the beginning and middle stages of infection. CRP increases within the first 6 hours of infection and reaches its maximum concentration at 24-48 hours (Thurnham et al., 2003). However, CRP concentration may not remain abnormally high long enough to detect the stage of early convalescence (Paracha, et al., 2000). Another APP, α_1-acid glycoprotein (AGP) may be needed post-infection for immunomodulatory effects, and is considered to be useful for detecting cases where infection has subsided, but retinol concentrations still may be reduced as total recovery has not yet occurred. (Thompson, et al., 1992). AGP is much slower to rise than CRP, and achieves its maximum concentration 2-5 days after infection (Thurnham et al., 2003).

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[20] An alternative classification also encountered is to define deficient as less than 0.35 μmol/L and low as greater or equal to 0.35 μmol/L and less than 0.70 μmol/L (an example can be found in Takyi, 1999). However, public health assessments of vitamin A status most often report the percentage of all children falling below 0.70 μmol/L and that is the approach used here. Vitamin A deficiency is considered to be of public health importance if at least 15% of a defined population has plasma retinol concentrations under 0.7 μmol/L or 5% has plasma retinol concentrations under 0.35 μmol/L (Sommer and Davidson, 2002).

Thurnham et al, 2003 combine these two types of indicators to classify the stages of sub-clinical infection to help determine its effect on plasma retinol. Stage 1 is the "incubation" period defined by AGP as 1 g/L or less, but CRP is greater than 5 mg/L. Stage 2 represents the infectious stage or period of early convalescence when both markers are raised above their respective cut-off points. Stage 3 is defined as the convalescence stage in which AGP is greater than 1 g/L, but CRP is 5 mg/L or less.

Research is on-going to determine whether assessing APPs alongside serum retinol can permit the determination of correction factors to allow for the reduced level of serum retinol concentrations in populations with on-going infections. To date, no linear relationship has been established between a change in inflammatory proteins and serum retinol status (Tomkins, 2003). However, a meta-analysis of 15 studies of apparently healthy individuals (Thurnham, et al., 2003) provided estimates of percentage reduction in plasma retinol for individuals with infection compared to healthy individuals. Moreover, the authors suggest that an alternative approach to estimating vitamin A deficiency would be to use plasma retinol values of only those individuals classified as healthy, as indicated by the lack of raised APPs. Their suggested approach is to define apparently healthy individuals as those with CRP lower than 5 mg/L and AGP lower than 1.0 g/L. Clearly, the ability to do this will be driven by sample size considerations, as the number of healthy individuals needs to be high enough to provide reliable estimates.[21] To simplify terminology, this report will refer to children exhibiting elevated CRP values (above 5 mg/L) or with elevated AGP values (above 1.0 g/L) as "ill" at the time of measure, recognizing that these proteins are only markers indicating the probability of infection at a certain stage, not the actual illnesses.

6.2 Results of the Serum Retinol Analysis

As described in the methodology section, for ethical reasons the study is designed to test the ability of the food-based intervention based on OFSP to maintain serum retinol status. After having their dried blood spot samples taken, all children received vitamin A capsules at Round 1 and Round 2 when OFSP was still in the introductory stage. In principle, no reference child received a vitamin A capsule *from the project* between Round 2 and Round 4, approximately a 12-month period. Control children, however, could have received a capsule via routine health services during that period. In this section, the results for the full sample will be presented, followed by results for the sample of healthy children.

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[21] Maqsood et al. (2004) argue against excluding individuals with elevated APPs to improve prevalence estimates of vitamin A deficiency because, they argue, it will lead to sampling bias, which in turn could lead to underestimating the prevalence of vitamin A deficiency. Using data from the Marshall Islands, they demonstrated that the age, gender, prevalence of anemia and hospitalization history was significant between children with and without elevated acute phase proteins. However, because of their small sample sizes, they were unable to substantiate their second hypothesis, namely, that children with night blindness were more likely to have elevated APPs then children without. While the age and sex composition of Sample 1 healthy children were significantly different than the overall sample, our conclusion was that the amount of bias introduced by using the healthy sub-sample was overshadowed by the probably greater bias introduced by retaining non-healthy children in the sample.

The distribution of the serum retinol measures for all children participating in the final round of the survey, Round 4, is shown in Figure 6.1. The mean for the entire sample is 0.713 ± 0.26 µmol/L. The sample is not normally distributed, with the median value of 0.690 being slightly lower than the mean.

For the purpose of comparing results between control and intervention reference children, within and between rounds, two sub-samples are defined. Sample 1 excludes the eight intervention children who received vitamin A capsules between Round 2 and Round 4, whereas the rest of the intervention cohort received placebos. Between Round 2 and Round 4, 24 control children received capsules from local health facilities, 9.8% of the control children in the final sample. This low coverage of the control sample is not surprising, as the average age of children in the final sample is 34.8 months, and regular health facility visits fall off dramatically for children once they have completed their vaccinations. In Sample 1, control children receiving the capsules are retained in the sample as this represents the alternative scenario to the food-based intervention in the study setting for young children over one year of age. That is the probability of receiving a vitamin A capsule in rural Zambézia through the current system of distribution as a part of routine clinic services is approximately one out of every ten children. The sample size for Sample 1 is 733 children, and descriptive statistics are essentially equivalent to those for the entire sample. In Sample 2, both the intervention and control children receiving capsules between Round 2 and Round 4 are dropped, reducing the total sample size to 709 children. Unless otherwise indicated, all results in this section are based on Sample 1.[22]

Table 6.1 compares the basic characteristics of the sample at Baseline (Round 1) and at the end of the survey (Round 4). At Baseline the average age of the cohort is 17 months, 45% of the children are male, 55% female, and 62% of the children were breastfeeding. Mean serum retinol was 0.605 ± 229 µmol/L. There was no significant difference in these characteristics or mean serum values between intervention and control areas. Only Intervention children had significantly slightly higher mean hemoglobin levels (8.4 g/L) than control children (8.0 g/L) at Baseline ($p = 0.02$). By the end of the study period, the reference children on average had aged to 35 months of age, and the percent of children still breastfeeding had dropped to only 7% of intervention children and 4% of control children. No significant difference existed in mean hemoglobin levels between the areas, with an overall mean of 9.7 g/L. Mean hemoglobin values are 1.3 g/L higher overall in Round 4 than at Baseline.

Mean serum retinol values at Round 4 were significantly different ($p = 0.001$) with intervention children showing higher values of 0.735 µmol/L compared to control children with 0.670 µmol/L. Median values differed by 0.043 at Baseline and 0.071 µmol/L at Round 4. To illustrate the shift in distribution of serum retinol between the first and last rounds, cumulative density functions for both periods are shown in Figure 6.2.

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[22] Note that the intervention sample retains all intervention households that participated in the study regardless of the amount of OFSP they grew or the extent to which they participated in project activities. Likewise, the control group retains the seven households who procured OFSP on their own.

Both groups have shifted to the right, reflecting overall improvement. But the area separating the control and intervention group increases in Round 4 compared to the Baseline.

The shifting of the distribution can be explored through examining changes in the percentages of children falling below established cut-off points. Table 6.2 summarizes the characteristics and status of the children at Baseline. At Baseline, 71% of the children were classified as deficient (below 0.70 µmol/L), with no significant difference between the intervention and control areas. Severe vitamin A deficiency (<0.35 µmol/L) affected almost 11% of the children, again with no difference between areas. Twenty-three percent of children fall below the cut-off point used by the Mozambican Ministry of Health for low hemoglobin status, 7 g/L.[23] This prevalence also does not differ significantly between areas. However, CRP levels were significantly higher among control children. Control children averaged 9.4 mg/L compared to 7.8 mg/L for intervention children[24]. Consequently, 74% of control children were classified as ill at Baseline compared to 59% of Intervention children.

By Round 4, the children had improved considerably both in health, and in vitamin A and iron status (Table 6.3). Prevalence of vitamin A deficiency was significantly lower among intervention children (47.6%) as compared to control children (58.0%). Three percent of the children had low hemoglobin, with no differences seen between areas.

Only 8.6% of children were under two years of age at Round 4, whereas three quarters were at Baseline. Older children have more developed immune systems, and levels of acute infection (reflected by elevated CRP) were much lower than at Baseline—35.5% of study children. However, in contrast to the situation at Baseline, at Round 4 mean CRP levels were significantly higher ($p = 0.04$) for intervention children (7.0 g/L) than for control children (5.6 g/L). There was no significant difference in the prevalence of children with elevated CRP (>5 mg/L) between the areas, with 35.5% of Sample 1 classified as "ill". In Round 4, an additional acute phase protein was analyzed, AGP. Mean values of AGP are significantly higher ($p = 0.000$) in intervention (0.71 g/L) than control areas (0.62), but similar to the case for CRP, differences between study areas in terms of percentage of children classified as having elevated AGP are not significant, with 12.6% of the sample having AGP values equal to or exceeding 1.0 g/ml. In Round 4, cut-off values for the two APPs are combined to create a category of "apparently healthy", capturing all children who do not have elevated levels of either CRP or AGP. Using this criterion, 60.8% of the sample children are apparently healthy, and no

[23] Improving iron status was not a specific goal of the project. Hemoglobin status was assessed at Baseline and at Round 4 only to serve as a control variable in interpreting serum retinol status. At Baseline, children with low hemoglobin status were given referral notes (*guias*) requesting the nearest health facility to investigate the cause of low status, most likely due to malaria or poor iron intake or both. Since local health facilities were found not to have any iron sulfate in stock, the project provided tablets to facilities likely to receive project referrals.

[24] The means of CRP and AGP should be interpreted with caution. Limits in precision in equipment used to determine CRP at Craft Laboratories meant that all values below 0.5 mg/L were reported as 0.50 mg/L and all values above 40 mg/L were reported as 40 mg/L. The upper limits of precision measurement for AGP were not reached. However, all values of AGP below 0.18 g/L were rounded to 0.18 g/L.

significant differences exist between intervention and control children, in contrast to the Baseline situation.

The correlation between the two APPs in Round 4 is positive and strong with r = 0.539.[25] As expected, the relationship between each APP and serum retinol was significant and negative, with the correlation between CRP and serum retinol (-0.361) being higher than that between AGP and serum retinol (-0.160). No significant correlation exists between the age of the child at Round 4 and serum retinol status. However, age was significantly and negatively correlated with CRP (-0.110) and AGP (-0.157).

The contrast in prevalence of vitamin A deficiency between rounds and between all children and healthy children in Round 4 is shown for Sample 1 in Figure 6.3. Rates of deficiency drop significantly for both intervention and control children between the Baseline and Round 4, but Round 4 prevalence is significantly lower for intervention children (a 10% difference in prevalence). As summarized in Section 6.1, illness, flagged by APPs, can transiently depress serum retinol levels. Thus, it makes sense to examine differences in prevalence among apparently healthy children. For this sub-group, the contrast between intervention and control children at Round 4 is sharper, with 36% of intervention children deficient, as compared to 53% of control children.

Table 6.4 describes the key characteristics of this healthy sample at Round 4. The potential for bias is limited since the differences between the sub-sample of apparently healthy children and the overall sample are small: the sub-sample has 1.2% fewer children below 2 years of age, 3% fewer boys and 1.4% fewer children breastfeeding than the overall sample. There are no significant differences between the areas for healthy children in the mean age, proportion of males, and proportion of children breastfeeding.

Mean serum retinol for healthy intervention children is 0.811 μmol/L compared to 0.712 for control children (Table 6.5). This 0.099 μmol/L difference is significant (p = 0.000) and the difference between median values, perhaps more representative in this non-normal distribution, is even greater: 0.141 μmol/L.

If we use the APPs to define stages of infection, the pattern that emerges is presented in Table 6.6. In the intervention area, the mean value for healthy children (0.81 μmol/L) is significantly different (p = 0.01)[26] when compared to each stage of infection individually, but no significant differences exist between the remaining three stages. The overall mean of the homogenous sub-group of ill intervention children is 0.63, implying that serum retinol has been suppressed due to illness by approximately 22%. This is close to the value of 25% found by Thurnham et al. (2003) in their meta-analysis separating apparently healthy children on the basis of CRP values greater than 5 mg/L.

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[25] Given that none of the three variables (serum retinol, CRP, AGP) are normally distributed and CRP and AGP are truncated at the extremes, Spearman's rho was calculated. All correlations were significant, with p = 0.000, except for the p-values between age and CRP (p = 0.003).
[26] One-way ANOVA, Scheffe's test.

For the control group, a significant difference exists only between the mean of the healthy children (0.71 µmol/L) and Stage 1 children (0.60 µmol/L)[27], reflecting a suppression of approximately 15% due to illness. Small sample sizes for the Stage 2 and Stage 3 control children in part explain the lack of difference between healthy children and these two sub-groups of ill individuals. The mean difference of 0.10 µmol/L in serum retinol between healthy children in the intervention and control areas is significant, but the small difference between the ill children (0.02 µmol/L), combined from all stages is not[28].

AGP was only collected in Round 4. As shown in Table 6.7, an additional 27 cases (3.7% of the sample) of ill children are detected that would not have been identified if only CRP had been obtained. Since in rounds 1 and 2 only CRP was collected, healthy status will be defined on the basis of CRP only. However, it is highly probable that some children may have been misclassified as healthy in those rounds when in fact they were not.

Part of the significant drop in levels of vitamin A deficiency between the Baseline and Round 4 for the entire sample is no doubt due in part to improvements in health status, particularly in the control areas. Figure 6.4 presents the percent of apparently healthy children in both areas, based on the APP measures taken, for rounds 1, 2, and 4. The number of children with non-elevated CRP status doubled in the control areas from between Baseline and Round 2 from 26% to 56%, whereas the percent of healthy children in the intervention areas increased from 41% to 53%. Health status continued to improve between Round 2 and Round 4, though not as dramatically. When children are classified as apparently healthy in Round 4 based only on the CRP criterion available for the previous rounds, 63% of Intervention children and 67% of Control children are considered healthy. When the additional criterion of having non-elevated AGP status is also considered, these percentages drop to 60% and 63%, respectively.

The level of morbidity at the end of the study remains high, even though it improved substantially from Baseline as would be expected due to the aging of the cohort. Zambézia is characterized by endemic malaria, poor sanitation, and low drinking water quality. Moreover, during the study period, the government had no policy regarding de-worming young children and it is highly likely that parasitic infestation was high.

Table 6.8 presents the characteristics of apparently healthy children at Baseline. Rates of deficiency are not significantly different for intervention and control children at Baseline, average 58% for the entire sample. Figure 6.5 compares the prevalence rates of serum retinol deficiency in children with low acute phase protein levels at Baseline and at Round 4. Using the same CRP criteria to separate non-acutely ill children (CRP<5 mg/L), prevalence of vitamin A deficiency in Intervention children drops from 60% at Baseline to 38% at Round 4. However, among control children deficiency levels remain at the same level, 52% at Baseline versus 53% at Round 4. When the definition of healthy is modified to include low AGP status, the vitamin A deficiency level

[27] One-way ANOVA, Scheffe's test.
[28] Mann-Whitney test, p=0.000 for apparently healthy children sub-sample.

for intervention children drops an additional 2%, whereas that for control children remains the same.

As expected, when control children receiving capsules are excluded (Sample 2), prevalence of deficiency is slightly higher for this group and the difference in prevalence between the two areas is slightly larger (a 19 percentage-point difference; see Figure 6.6).

The cumulative density functions for Sample 1 at Baseline and at Round 4 (Figure 6.7) illustrate how the distribution of serum retinol has improved for healthy intervention children and failed to noticeably improve for healthy control children.

6.3 The Health Environment and the Relationship between Reported Morbidity and Acute Phase Proteins (APP)

As mentioned previously, acute phase proteins are markers indicating the probability of infection or inflammation, not the illnesses themselves. At the time of measurement of the biological indicators, caregivers were asked to recall if the reference child had suffered from any symptoms/illnesses during the two weeks prior to the survey. This information provides an indication of what the dominant health problems are in the area and permits an exploration of whether any relationships can be detected between reported morbidity and acute phase proteins.

Tables 6.9-6.11 present reported prevalences for common childhood symptoms of illness for Round 1 (Baseline), Round 2, and Round 4 (end of study) for intervention and control households. Overall, a decreasing trend similar to that seen with serum CRP was observed with mother's recall of morbidity of a reference child with respect to infections such as diarrhea, acute respiratory infection (ARI), fever and any other diseases over the two weeks prior to each survey round. No significant differences were found between control and intervention areas in terms of mother's recall of the presence or absence of diarrhea, ARI or fever in the reference children for all the 3 rounds. However, for Round 4, prevalence of "other" disease was significantly higher in control (10.4%) than intervention (4.4%) areas. "Other" symptoms/conditions reported in Round 4 were mainly abscesses, wounds, eye infections and stomach ache.

For all the three rounds, fever was reported as the most prevalent symptom followed by diarrhea based on a significance level of 0.05. In the two weeks before Baseline, more than 60% and about 40% of children reported to have experienced fever and diarrhea, respectively, but these figures decrease to only about 40% and 24%, respectively, in Round 2 and, 25% and 9%, respectively in Round 4. Although ARI was the least reported infection compared to diarrhea and fever, about 1 in every 5 children was reported to have suffered from ARI two weeks prior to Baseline. The prevalence, however, decreased to only 6.6% and 2.2% in rounds 2 and 4, respectively.

In addition to comparing prevalence of discrete illnesses we assessed whether or not each child had ANY illness in the past 2 weeks (diarrhea, fever, ARI, or "other"). The proportion of children in the entire sample identified as having any form of illness was

80.8% at Baseline with no significant difference between intervention (82.1%) and control (78.2%) areas. These percentages dropped to 61.1% for the overall sample in Round 2 with a significant difference between intervention (65.5%) and control (52.3%) areas ($p < 0.001$; Fisher's exact chi-square test; two tailed). In Round 4, no significant differences existed ($p = 0.293$) between the two areas, with 36.8% of reference children reported as being ill.

In rounds 2 and 4, recall of measles and presence of other serious disease apart from measles was for an extended period of time in contrast to the two-week recall period for the previously mentioned diseases. No significant differences in prevalence for either of these two variables exist between intervention and control areas. Recall for measles in Round 2 was done over the period of January–December 2003 and for Round 4 it was done over January-December 2004. The prevalence of measles in Round 2 was 9.8% and that of Round 4 was 0.8%. This difference is explained by a significant measles outbreak throughout the country in late 2003.

The recall of whether or not the child had serious illness apart from measles was done over a 6-month period in 2003 (Round 2) and over a 1-year period in 2004 (Round 4). The prevalence of this variable was 10.6% Round 2 and 7.4% for Round 4.

The extent to which mother's recall of infection in the past two weeks correlates with levels of serum CRP and AGP (i.e., the biomarker of presence of infection in reference children) was explored using Spearman's correlations (Table 6.12). The correlation coefficients were found to be very small overall for all the reported infections in all rounds and with the exception of fever, none was found to be statistically significant. The magnitude of the correlation coefficient between high serum CRP and fever was found to be small, around 0.1 for all the 3 rounds but the relationship was positive and consistently significant ($p < 0.05$; two tailed test). Similarly, in Round 4, the correlation coefficient for the relationship between fever and AGP was small in magnitude ($r = 0.076$) but significant ($p < 0.05$; two tailed test). These results are not surprising since, as explained in section 6.1, elevated APP does not equal clinical illness and values of CRP between 5 and 10 mg/L may correspond to incubation periods of illness. The decreasing trend in prevalence of infection from survey rounds 1 to 4 as seen with both high serum acute phase proteins and morbidity recall data reflect the increasing resistance of young children to infection as they progress in age. This is expected because, all things being equal, increase in age of young children is associated with better development of the immune system to withstand the pressures of repeated infections in their environment. In resource-poor areas like rural Mozambique, infections such as malaria are very prevalent and repeated infection with malaria results in the development of an adaptive immunity, which enhances an individual's resistance against future exposures to the parasite. The prevalence of malaria is reflected in the high proportions of mothers reporting their child had fever, as compared to any of the other symptoms/illnesses.

The high levels of exposure to malaria and other illness means that any child living in this environment is likely to fall ill several times in a given year. This could significantly affect the ability of diet improvement to be translated into improved growth. It is interesting to note that in both areas across all rounds at least 10% of the population did not consult anyone outside the household for treatment of the reference child's illness (Table 6.13-6.15). However, the predominant forms of primary consultation for various infections outside the household are the health center and health post. In addition, traditional healers are utilized and, to some extent, consultations for treatment by other private persons sought. In general, there is no clear pattern in terms of the different illnesses for the kinds of consultation and no differences also exist between the different rounds for the kinds of consultation made for various diseases.

The mean cost of primary consultation for treatment does not give a clear explanation as to why people prefer some form of treatment to others. Seeking consultation from traditional healers happens to be more expensive than the other forms of treatments in general (Tables 6.16-6.18). Seventy-two percent of round 2 respondents reported that they accessed the health facility they most commonly used by foot and 54% indicated that a traditional healer lived within their village. Thus, the higher apparent average cost of traditional healers may be off-set at times by their closer proximity than the health facility.

6.4 Results of Analysis of Anthropometric Indicators of Nutritional Status

Results are presented for Baseline and Round 4. Mean age did not differ between intervention and control children; mean age was 17 months at Baseline and 35 months at Round 4.

Table 6.19 summarizes z-scores and MUAC for both treatment groups. Mean height-for-age Z-scores (HAZ) and weight-for-age z-scores (WAZ) were significantly lower among the control children at Baseline. This difference was maintained across rounds. Mean WHZ differed at Baseline but the difference was not significant; at Round 4 mean WHZ was significantly lower among children in control communities. Mean MUAC did not differ between the two groups either at Baseline or Round 4.

In contrast to results for mean z-scores, the prevalence of stunting and low weight-for-age did not differ between groups at Baseline (Table 6.20). The difference in prevalence of stunting approached significance in Round 4 ($p = 0.051$), with higher prevalence among children in the control communities (54%) than in intervention communities (46%). Prevalence of low weight-for-age was significantly higher among control children at Round 4 (42% vs. 33% in intervention areas). Prevalence of wasting was significantly lower in intervention areas both at Baseline and at Round 4.

Because of the Baseline differences, it is most useful to look at change in z-scores, MUAC, and prevalence of low z-scores between Baseline and Round 4. Tables 6.19 and 6.21 summarize information on these changes. Table 6.19 shows that none of the changes in mean z-scores differed significantly between intervention and control areas. Table 6.21 shows that the change in prevalence approached significance for stunting ($p = 0.08$) and was significant for low WAZ ($p = 0.03$). However, the magnitude of the difference was not large, with a 15 percentage-point decline in prevalence of low WAZ in the intervention area as compared to an 11 percentage-point decline in the control area. The change in prevalence of wasting did not differ between the two groups.

Identical analyses were performed for two sub-groups of children. First, we examined results for children who were under 12 months of age at Baseline. These are the children who were exposed to the intervention across the age range where most growth faltering occurs (Shrimpton et al., 2001) and who also have the most potential to benefit (Lutter et al., 1994; Shroeder et al., 1995). Secondly, we examined results separately for children with very low Baseline serum retinol (<0.35 μmol/L). In supplementation trials, vitamin A has shown an effect on growth primarily among children with very low Baseline levels (Rivera et al., 2003).

The group of children under 12 months at Baseline had a mean age of 8 months at Baseline, and 26 months at Round 4. There were no differences in mean z-scores or MUAC at Baseline or in Round 4, and there were no differences in the changes in z-scores or MUAC. There were also no significant differences in prevalence or changes in prevalence, but this may be due to lack of statistical power to detect changes in this sub-group. Table 6.21 shows that among this vulnerable age group, increases in prevalence of stunting and low weight-for-age were approximately 10 percentage points larger in control areas.

Mean age at Baseline for the sub-group with very low Baseline retinol was very similar to the overall group, at 17 months. The sample size was very small (n = 78), yielding limited statistical power. Table 6.20 summarizes differences in prevalence of low z-scores in each group. Again, none of the between-group differences were significant at Baseline, but Round 4 differences, particularly in the prevalence of low weight-for-age, are quite large. At Round 4, 39% of children in the intervention areas had low WAZ, as compared to 63% in the control area.

6.5 Discussion of Findings Concerning Young Child Nutritional Status

The Towards Sustainable Nutrition Improvement Project sought to address two major nutritional problems among children under five years of age: vitamin A deficiency and inadequate caloric intake. In addition to promotion of production and consumption of beta-carotene-rich sweetpotatoes, the project included behavior change communications (BCC) featuring a number of messages related to child-feeding practices (e.g., exclusive breastfeeding to 6 months, giving enriched porridges from 6 months, frequency of feeding, importance of vitamin A-rich foods and fat sources daily, etc.).

The results strongly point towards a significant difference in vitamin A intake and serum retinol status between intervention and control children at the end of the study period. Households in intervention areas received OFSP and participated to varying degrees in extension and promotion activities. Mean levels of serum retinol were significantly higher in intervention than control children. Measurement of acute phase proteins allowed us to exclude children whose serum retinol was likely to be transiently depressed due to infection. Healthy intervention children have serum retinol values 0.10-0.14 μmol/L higher than control children. At the end of the study 36% of healthy children in the intervention areas were vitamin A deficient, compared to 53% in control areas. In Round 4, levels of serious deficiency (0.35 μmol/L) among healthy children were also significantly lower (0.7%) in intervention areas than 3.9% in control areas[29]. This reflects a significant decline from the Baseline value of 4.0% for healthy children in intervention areas, but no significant change for the 3.1% figure for severe deficiency in control areas.

While vitamin A deficiency had not been eliminated, it had been substantially reduced from 60% to 36%, or by 24%, among apparently healthy intervention children in an extremely resource-poor environment. As a comparable reduction did not take place among healthy control children, of whom over half remained deficient at the end of the study, the results suggest that the difference in levels of deficiency may be attributed to the intervention.

Given the range of the nutrition intervention, and the objective of increasing caloric as well as vitamin A intakes, it is appropriate to assess anthropometric indicators for evidence of impact on child nutritional status as reflected in z-scores and MUAC. Because we know that children are most likely to benefit from early and sustained intervention (Lutter et al., 1994; Shroeder et al., 1995), it is also appropriate to consider impact on the sub-group of children who were less than one year old at Baseline. Finally, children with very low serum retinol at Baseline may also constitute a sub-group with more potential to benefit from a major increase in vitamin A intake; impacts on growth have been observed for this sub-group, and not others, in vitamin A supplementation trials (Rivera et al., 2003). However, for these latter two groups (youngest children and children with very low Baseline serum retinol), the statistical power to detect differences is limited.

Because of Baseline differences in mean z-scores between intervention and control areas, it is most meaningful to look at differences in mean change from Baseline to Round 4 in each group. When all reference children are considered together, there were no significant differences in the mean changes in z-scores between groups. The change in prevalence between WAZ at Baseline and Round 4 was significant; however the magnitude of the difference was not extremely large. In summary, for the intervention area children as a whole there is no strong evidence of impact on nutritional status, as reflected in z-scores or MUAC, and as compared to the control area.

There are many possible explanations for a lack of impact. In the case of linear growth (HAZ), many nutrients may be limiting, including protein, iron, zinc, calcium, phosphorus, vitamin A, riboflavin and others; lack of a nutrient may directly or indirectly (via anorexia or morbidity) limit growth (Gibson and Hotz, 2001; Rivera et al., 2003). Depending on the local diet, any or all of these may be the key nutrient(s) limiting linear growth. If an intervention succeeds in increasing intake of some but not other key limiting nutrients, an impact on HAZ is unlikely. Secondly, in contexts where prevalence of infections (chronic and acute) is very high as is the case in the study area, improvements in diet may be insufficient to provide an impact on nutritional status; and,

[29] Mann-Whitney test for non-normally distributed samples ($p = 0.014$).

infections may negatively impact nutritional status through increasing nutrient needs, decreasing appetite and intake, and/or increasing nutrient losses (Bhan et al., 2001).

Finally, potential to benefit from a particular intervention may be limited to sub-groups. In the case of this intervention, the BCC appropriately focused on messages related to the first two years of life. This meant that for mothers whose children were already past infancy at Baseline, some messages came too late for the full benefit of the two-year intervention to accrue to their child. Among the sub-group aged less than 12 months at Baseline, results suggest the possibility of a positive intervention impact on changes in prevalence of stunting and low WAZ, but the differences are not significant. Children in the intervention areas also did not show the marked increase in wasting that is typical in this area for a cohort moving from infancy into the second year of life.

Similarly, if vitamin A deficiency was limiting growth, it could be hypothesized that only the subgroup with very low Baseline serum retinol could show a response in indicators of growth. Among the small sub-group with very low serum retinol at Baseline, changes in prevalence of low z-scores appeared even larger, in favor of the intervention group, but again did not reach statistical significance. As noted, statistical power was limited in these sub-group analyses.

In conclusion, whereas evidence for strong impact on child growth is limited, evidence for strong impact on vitamin A status exists in spite of extremely poor sanitary and health conditions found in the study area. We emphasize that these results were obtained over what constitutes a very short timeframe for an agricultural and behavior change intervention. Subsequent regression analyses will enable us to investigate and measure the contribution of various biological, socio-economic, demographic, production, and consumption factors to this difference.

7. CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

7.1 Summary of Key Conclusions

The previous sections sought to explain the environment in which the 2-year pilot study was conducted and ascertain whether the integrated agriculture-demand creation-market development approach using orange-fleshed sweetpotato (OFSP) as a key entry point succeeded in impacting young child vitamin A intake and serum retinol status. Previous sections sought to answer eight key questions. In this section, the principal findings are summarized for each of these questions.

1. Were the introduced OFSP varieties acceptable to both producers and consumers, in terms of agronomic performance and organoleptic qualities?
Five of the nine introduced OFSP varieties (Resisto, Jonathan, CN-1448-49, LO 323, and Japon) were accepted by farmers, both men and women, in terms of taste and agronomic performance in a difficult agro-ecological setting. Households responded to market and production incentives by expanding the area under production in year two, increasing average plot sizes by approximately 10 times, from 33 to 359 square meters. Whereas no household produced at least 500 square meters of OFSP in 2003, 35% did in 2004.

Resisto emerged as the most popular of the nine introduced OFSP varieties because of its good taste and appearance, good yields relative to other OFSP and local varieties, prostrate (spreading) growth structure, and tendency to produce the medium-sized (200-300 gm) roots preferred by the commercial market. Jonathan, CN-1448-49 and LO 323, however, are more resistant to drought conditions. Although their erect growth structure is not preferred by producers, their vines are hardier and more likely to be retained for subsequent plantings under harsh drought conditions. On-farm yields of sweetpotato range from 6-15 tons/hectare under the poor soils and rainfed growing conditions of the Low Altitude zone of Zambezia Province. Eighty-six percent of intervention households reported that OFSP was higher yielding than local white-fleshed varieties. However, crop cuts indicate that yields vary considerably across sites and overall it is best to consider yields between the local and the best introduced clones as comparable under poorer rainfall conditions, with OFSP being superior under normal rainfall conditions (yields of 10-15 tons/hectare).

The market development campaign contributed significantly to improving the quality and quantity of OFSP roots produced in the second year and creating demand among consumers. An innovative grading scheme tested with a pilot trader enabled farmers to obtain a higher price per kilogram (1500 MT/kg) for first quality roots than for second quality roots (1000 MT/kg) and third quality roots were not purchased, guaranteeing root availability for home consumption. Painted market stalls and walls with promotional messages for both OFSP and other vitamin A rich foods, radio programs, community theater performances, hats, and *capulanas* (lengths of cloth used as skirts) created an awareness of the importance of vitamin A in the broader community and among potential new consumers of OFSP. Knowledge of the association of OFSP as a source of good health and vitamins became widespread. By the end of the study, market demand for OFSP clearly existed with indications that a significant number pf producers and consumers are developing a distinct preference for OFSP over white-fleshed sweetpotato.

2. Did participant households process sweetpotato and diversify its use?
There is a clear preference for fresh root consumption, however, there was willingness to diversify how sweetpotato is prepared, particularly for young children, and significant adoption of a modified technique for drying sliced chips for later consumption. Processed product development for sale was of greater interest to those already producing those products in rural markets than for study participants.

The dominant traditional practice of just boiling (usually with small amounts of water) or steaming sweetpotato and eating them whole is positive, because beta-carotene retention is much higher than when sweetpotato is fried, baked, or chopped into small pieces. However, in the case of young children in particular, enriching OFSP with fat and protein is desired to assure greater absorption of vitamin A (through the presence of a small amount of fat), greater energy density, and increased intake of other essential nutrients for good growth. At Baseline, only 5% of study women reported ever having made porridge using sweetpotato even though 69% of households produced sweetpotato. In 2004, 74% of intervention households made sweetpotato porridge, while only 3% made sweetpotato porridge in the control areas.

Processing sweetpotato into dried chips extends its availability throughout the year and the recommended method builds on an existing traditional practice. Farmers were encouraged to dry under the shade of a tree instead of under direct sunlight to preserve beta-carotene content. In 2004, 39% of intervention households dried OFSP, and 75% of those followed the recommended practice of shade drying. Samples of chips dried under local conditions showed good beta-carotene content for the darker orange-fleshed Resisto variety (ranging from 716-1,050 µg RAE/100 gms) and much lower content in light orange-fleshed CN-1448-49 (165-191 µg RAE/100 gms). Therefore, use of darker orange-fleshed varieties such as Resisto for chipping and drying is superior to use of light orange-fleshed varieties like CN-1448-49. However, contrary to expectations, the beta-carotene in the samples dried in direct sunlight was not completely destroyed. Average levels for Resisto were only 21% lower in direct sunlight than for treatments not in direct sunlight.

Fresh root storage in protected pits with a bamboo breathing tube for respiration was tested in year 1 by project staff, and demonstrated with farmer's groups in year 2. Group trials indicated that fresh, disease free sweetpotato roots in protected pits could last 5-6 months with minimal losses of roots. Studies are needed, however, on the retention of beta-carotene in roots stored in pits over time..

Sweetpotato leaf consumption was also promoted. Eighty percent of intervention households consumed sweetpotato leaves in 2004, compared to only 46.7% of control households.

The processing of OFSP into juice was also introduced into groups but use is limited by the availability of other ingredients need to make the juice (citrus fruit which is

seasonally available and sugar, which must be purchased).
Golden bread proved to be an economically viable processed product for rural markets in the study area. Bread is one of the first processed products produced in rural markets when wheat flour is available and, when available, is widely consumed by the rural poor. Golden bread increased profit margins of bakers in the 3 sites pilot tested by 50-92%. The majority of consumers preferred golden bread to white bread because of its heavier texture and golden color. Laboratory analysis conducted by Paul Jaarsveld of the Medical Research Council in South Africa on bread samples from 5 OFSP varieties showed that dark orange-fleshed varieties like Resisto produce buns with sufficient trans-beta-carotene content to be considered excellent sources of vitamin A for young children and good sources for adults. For a child 1-3 years of age a small bun of 60 gms made with Resisto would contribute 25% of daily vitamin A needs, whereas a medium-sized bun of 110 gms provides 45%.

3. Did the intervention result in increased levels of nutritional knowledge among both female and male principal caregivers in the household?
To roughly quantify the change in nutritional knowledge over time, a nutritional knowledge index with a maximum value of 12 was constructed to compare change in nutritional knowledge between Baseline and the end of study for principal women and men responsible for the care of the reference child. There was no significant difference in the mean value of knowledge index between intervention and control women at Baseline ($p = .315$) nor intervention and control men ($p = .293$). Intervention women at the end of the study have means almost twice that of women in control areas (8.1 versus 4.3, respectively), and over twice the value of their mean at Baseline (3.2). Intervention men also have a significantly higher mean (6.3) than control men (4.7) at the end of the study, and their mean also almost doubled since Baseline (3.4). Control women also significantly improved their knowledge by a small amount between Baseline and the end of the study, as did control men. This is most likely due to exposure to provincial radio campaigns.

To understand the factors contributing to the improvement in the nutritional knowledge score among women in the intervention areas, a linear regression model was employed to investigate how various factors contributed to the change in the nutritional knowledge score between Baseline and the end of the study (round 4). Results indicate that when age, formal education levels, and other characteristics of the women and household are accounted for, receiving additional home visits made no significant contribution to changes in nutritional knowledge. Attending the group sessions emerged as a key factor enabling improvement in knowledge. Yet 18% of intervention women attended fewer than 6 sessions. The main reasons for women missing sessions were being ill themselves or having to care for other family members who were ill. Thus, the poor health environment characterizing this part of Zambézia is the dominant factor affecting women's ability to attend group sessions and improve their nutritional knowledge.

4. Is the increased awareness of the importance of vitamin A rich food reflected in changes in food purchasing patterns?
The conceptual framework hypothesized that greater awareness of the importance of vitamin A rich foods, combined with increased incomes from the sales of sweetpotato roots, could lead to purchase of more vitamin A rich foods in the market place, which in

turn could contribute to increased vitamin A intake.

Results from food expenditure information collected in a sub-sample of study households (28% of the total) indicate that households did not significantly alter their purchase patterns in favor of vitamin A rich foods. While mean monthly expenditures on vitamin A rich foods during the main harvest season in intervention household increased slightly between 2003 and 2004, no significant differences in expenditure on vitamin A rich foods was seen between intervention and control households in either year. However, future research should investigate whether expenditure patterns alter in seasons when OFSP is not available.

Intervention households find it easier to produce plant sources of vitamin A rich foods such as OFSP and papaya, than to produce animal sources such as eggs. There was a significant increase in the percent of households producing OFSP and papaya between 2003 and 2004. Neither purchase nor production of animal sources of vitamin A increased significantly between the two years.

Intervention households selling OFSP in year 2 were specifically queried on how they spent their funds. Only 13% used the money earned from sweetpotato sales to buy at least one vitamin A rich food. The main reason cited for not purchasing vitamin A rich foods is that they are perceived as being available "locally", and therefore one does not need to purchase them. The most common purchases made were dry fish, salt, clothing for children and women, soap, fresh fish, cooking oil and kerosene.

In these resource poor households, priorities for cash purchases are concentrated on food and non-food products essential for meeting basic needs that cannot be produced on-farm. Since some of the vitamin A rich foods can be produced on-farm, the perception appears to be that scarce cash resources do not have to be spent to buy different kinds of vitamin A rich foods than those that are produced. The one vitamin A rich source that is frequently purchased, fresh fish, was already part of the existing food expenditure pattern. There was no significant increase in the percentage of intervention households purchasing fresh fish or the mean amount spent on fresh fish between 2003 and 2004.

5. Did the intervention result in improved diet diversity and increased caloric and vitamin A intake at the household level?

Results indicate that the intervention succeeded in improving diet diversity, caloric and vitamin A intake at the household level during the post-harvest period (August-October), which coincides with the main sweetpotato production period. Since nutrient intake data were non-normally distributed, comparison of medians and the difference in distribution of intake levels is used as the basis for comparing household intake on an adult equivalent basis between intervention and control areas. Median household energy intake (2998 kcal) is 11.8% higher in intervention than in control areas (2681 kcal). The dominant sources of energy in the household diet are cassava flour, rice, and maize flour.

The difference in vitamin A intake is more dramatic: **median vitamin A intake at the**

household level in intervention areas (614 µg RAE) is 7.1 times higher than in control areas (86 µg RAE). The two dominant sources of vitamin A in the household diet were the orange-fleshed sweetpotato and papaya. OFSP was consumed by 34% of intervention households, in contrast to 3% of control households. Papaya was consumed by almost half the households in intervention areas, compared to approximately a quarter of households in control areas. The third most important source was fresh fish. Pumpkin and mango did not have the potential to be significant sources of vitamin A as they are not in season during the post-harvest period (August-October). **When OFSP was consumed in intervention areas, it contributed on average over 89% of the vitamin A ingested that day**. In contrast, on average, papaya when consumed provided 57% of the vitamin A intake in intervention areas, and 80% in control areas.

Nutrient intake results at the household level indicate that diet quality was higher in intervention households than control households but that there is still significant need to increase intake of many essential nutrients even in intervention areas. Median intakes of many other nutrients were also significantly higher among intervention as compared to control households ($p < .05$): vitamin C, vitamin E, vitamin K, iron, zinc, calcium, magnesium, folate, and the B vitamins except B12. No significant differences existed between median intakes of protein, lipid, retinol, selenium, phosphorus, vitamin B12 or phytate. A simple indicator of diet diversification at the household level is the number of ingredients used for preparing food during the last 24 hours. The mean number of ingredients used by intervention households is 7, a small but significant difference from the average of 6 ingredients used by control households. Improving diet diversity to a greater extent is seriously constrained by the limited number of crops that can be grown in this difficult environment and by lack of purchasing power.

6. Did the intervention result in improved caloric and vitamin A intake in children under-five years of age?

Based on the results of the 24-hour recall survey in the second year of the study, the intervention succeeded in improving the caloric and vitamin A intake in children under five years of age, relative to control children. Diet diversity was also higher among intervention children as compared to control children.

Mean intake of vitamin A was 7.8 times higher in intervention than control children, and median intake 8.3 times higher. Given that the RDA for children 1-3 years of age is 300 µg retinol activity equivalents (RAEs) and 400 µg RAEs for children 4-6 years of age, 100 grams of medium or darker intensity orange-fleshed sweetpotato could easily provide the RDA. Given the loss of vitamin A in processing, poor absorption, and illness, intake above recommended levels is highly desirable in an environment such as rural Mozambique. The median value for vitamin A intake for control children is extremely low at 56 µg RAE compared to 468 µg RAE for intervention children. If the entire sample of children is considered, including the two-thirds of children who did not consume OFSP on the day prior to the survey, OFSP contributes 31% of vitamin A intake to intervention children compared to 2.6% of intake in control children.

The project clearly achieved its objective of increasing vitamin A intake among young children through the introduction and promotion of OFSP, but not exactly as designed. The promotional message emphasized trying to feed at least a small amount of OFSP every day. In practice, children over 1 year of age ate large amounts (300 gms on average) 2-3 times per week coincident with the normal consumption practices among adults in the study area. Given that vitamin A can be stored in the liver, this alternative pattern of adoption probably has few negative consequences.

The project also achieved its objective of increasing energy intake among young children, which is most likely due to an increased number of meals per day. **Median energy intakes in the intervention areas (1339 kcal) exceeded control values (1225 kcal) by 14.2%.** More intervention than control children are consuming breakfast, and OFSP is principally being consumed as a breakfast food probably due to ease of preparation and the traditional perception of sweetpotato as a bread substitute. OFSP contributed on average 6% of energy intake. It is also contributing vitamins E, K, C, B2, and B6 in significant amounts.

Diet diversity was also higher among intervention than control children. A simple additive index was constructed, based on whether or not the child ate at least 10 grams of a given food group (except for fats/oils where the cut-off point selected was 5 grams of consumption), with the index ranging from 1 (only one food group consumed) to 9 (all food groups consumed). The mean number of food groups consumed by intervention children (4.0) was significantly higher than the mean number consumed by control children (3.4). **Intervention children succeeded in having more diverse diets than control children, principally through higher consumption of foods from three groups: vitamin-A rich roots (i.e., the OFSP), vitamin A-rich fruits and vegetables, and legumes and nuts (principally groundnuts).**

A particular concern, however, is the low level of fat intake. For study children, on average, only 11.1% of calories came from fat (median value) and no significant differences exist for fat intake between intervention and control areas. Although no minimum standards exist for fat intake, 2005 USDA dietary guidelines indicate that fat intake for 2-3 year olds should be between 30-35% of total calories. Fat enhances vitamin A absorption and increases the energy density of complimentary foods. Although the project distributed groundnut seed to non-coconut growing areas in 2004 and had specific messages advocating the addition of at least a teaspoon of fat to all main meals for the reference child, the fat constraint proved to be too difficult to overcome in the short time frame of the intervention project.

7. Is there significant improvement in vitamin A status, as measured by serum retinol, in children participating in the intervention areas compared to those not receiving the extension intervention in the control areas?

Evidence strongly points toward a significant difference in serum retinol levels between intervention and control children at the end of the study period. Households in intervention areas received OFSP and participated to varying degrees in extension and promotion activities. Control households received no direct extension intervention but may have listened to provincial-wide radio programs promoting the consumption of vitamin A rich foods, including OFSP. Only 27 control households received vines of OFSP through other sources during the course of the study. For the serum retinol analysis, eight intervention households that received a vitamin A capsule in 2004 were dropped from the analysis.

At Baseline, the average age of the cohort was 17 months, 45% of the children are male, 55% female, and 62% of the children were breastfeeding. Mean serum retinol was 0.605 ± 229 µmol/L. There was no significant difference in these characteristics or mean serum values between intervention and control areas.

By the end of the study period, the reference children on average had aged to 35 months of age, and per cent of children still breastfeeding had dropped to only 7% of intervention children and 4% of control children. Mean serum retinol values at round 4 were significantly different (p = .001) with intervention children showing higher values of 0.735 µmol/L compared to control children with 0.670 µmol/L. Median values differed by 0.071 µmol/L.

Shifting of the distribution was also explored by examining changes in the percentages of children falling below established cut-off points. At Baseline, levels of vitamin A deficiency, defined as the percentage of children falling below 0.70 µmol/L, are high but not significantly different in both areas, averaging 71% of the children. Severe vitamin A deficiency (<0.35 µmol/L) affects almost 11% of the children, again with the intervention areas not differing from the control areas. However, at Baseline, control areas exhibit significantly higher levels of the acute phase protein C-reactive protein. The acute phase proteins "mark" the presence of illness and several acute phase proteins (APP) can be used to help understand and control for the presence of infection. CRP levels for control children average 9.4 mg/L compared to 7.8 mg/L for intervention children. Consequently, 74% of control children are classified as ill at Baseline compared to 59% of intervention children.

By round 4, children improved considerably both in health and vitamin A status. Intervention children exhibit significant lower levels of vitamin A deficiency (47.6%) than control children (58.0%).

The collection and interpretation of acute phase proteins also enabled the transient depressing effect of illness on serum retinol measurement to be controlled for. Healthy intervention children have serum retinol values 0.10-0.14 µmol/L higher than control children. At the end of the study 36% of healthy children in the intervention areas were vitamin A deficient, compared to 53% in control areas. In Round 4, levels of serious deficiency (0.35 µmol/L) among healthy children were significantly lower (0.7%) in intervention areas than 3.9% in control areas. This reflects a decline from the Baseline value of 4.0% for healthy children in intervention areas, but no significant change for the 3.1% figure for severe deficiency in control areas.

While vitamin A deficiency has not been eliminated in the relatively short period for an agriculturally based intervention, it has been substantially reduced from 60% to 36%, or by 24% among apparently healthy intervention children in an extremely resource-poor environment. A comparable reduction did not take place among healthy control children, with over half remaining deficient at the end of the study. This suggests that the difference in levels of deficiency may be attributed to the intervention. Subsequent regression analyses will enable us to investigate and measure the contribution of various biological, socio-economic, demographic, production, and consumption factors to this difference.

8. To achieve change in vitamin A intake and overall serum retinol status, is it necessary to make home visits to principal female caregivers of young children or are group level extension visits sufficient?
No significant difference was detected in vitamin A intake or serum retinol status between children in intervention households receiving additional home visits and those just attending group sessions. Indications are that the home visits also did not significantly contribute to the improvement in nutritional knowledge index of the principal woman caring for the reference child. However, reference child intake of energy, protein, fat, and many other micro-nutrients was significantly higher in households receiving home visits than in those not receiving home visits. Further analysis needs to be done to understand the overall contribution of the home visits. Results to date indicate that substantial increases in OFSP consumption and other plant sources of vitamin A can be achieved through a communication campaign (radio, market promotions) and group sessions conducted by nutrition extension agents without requiring additional home visits. Improvement in other components of dietary quality for the young child may necessitate some kind of one-to-one contact between change agents and caregivers.

7.2 Discussion and Recommendations

Results show that existing OFSPs will not be rejected because of their highly visible trait (orange flesh) when introduction is accompanied by a well-designed demand creation campaign. In fact, most young children really like the taste of OFSP, evident by their average consumption rates of two medium-sized roots at a sitting. Radio and market promotion schemes are key components for awareness creation, particularly among consumers. The success of the pilot marketing experience is encouraging and argues for including a strong marketing development component based on commercializing OFSP roots using a grading scheme and promoting profitable processed products. Emphasis should be placed on medium-to-darker OFSP varieties to ensure sufficient beta-carotene content when they are dried or processed.

At the household level, the effort led by extensionists achieved significant success in spite of low levels of formal education among mothers and the resource-poor environment. Vitamin A intake and serum retinol improved in the reference children, and OFSP contributed significantly to that improvement. At the household level, modifying existing behaviors (for example, enriching complementary foods) proved easier than introducing new behaviors (for example, boiling water). A qualitative evaluation five months after the end of the intervention indicated that some messages were too complex for long-term retention, and some mothers felt frustrated by not being able to implement certain practices due to lack of resources. This raises the toughest issues in designing any food-based intervention project: How many crops or resource constraints can you effectively work on? Should orange-fleshed sweetpotato be promoted only as an add-on to existing agricultural programs or is greater impact achieved with this OFSP focused, multi-disciplinary approach? Further research is needed to compare the cost and benefits of these different approaches.

Projects need to establish how frequently they will review and adjust their key messages and even interventions in response to a community's ability to actually make desired changes in behavior. In a food-based intervention such as this one, however, major changes in approaches usually have to occur before the agricultural season gets underway. Adding additional crops means that extension staff has to be knowledgeable in the crop, seed has to be available for purchase, and an appropriate communication strategy designed. Training and re-training staff is an important but time consuming necessity that often places financial and time limits on a project's ability to modify its messages and approach as new constraints and opportunities are identified. Frequent changes in key messages can also lead to confusion among both extension staff and targeted community members.

If additional financial and human resources are available, serious consideration needs to be given to improving farmer access to a crop high in fat alongside OFSP promotion as improved fat consumption is an integral part of improving vitamin A status. Crops high in fat include groundnut, sunflower, sesame, cashew nut and avocado. As most of these crops are considered cash crops, the communication strategy would have to devise methods for working with households to assure some retention for household consumption.

The persistent problem of high morbidity levels, including their influence on the ability of caregivers to participate in training programs and role in constraining adequate nutrient intakes and child growth, raises the issue of to what extent agricultural programs can be linked with health service delivery programs and other community-based health and sanitation endeavors. The project intervention managed to achieve increased intake of vitamin A and several other nutrients and improved serum retinol status in a real world setting where at least a third of all children 1-4 years of age can be expected to be ill at any time. However, for the intervention children as a whole, the lack of strong evidence of impact on anthropometric nutritional status indicators (change in weight-for-height (WHZ), weight-for-age (WAZ), and height-for-age (HAZ) z-scores and arm circumference) compared to the control area is consistent with a situation where vitamin A is not the only factor limiting growth. In the case of linear growth (HAZ), many nutrients may be limiting, including protein, iron, zinc, calcium, phosphorus, vitamin A, riboflavin and others and lack of a nutrient may directly or indirectly (via anorexia or morbidity) limit growth. Depending on the local diet, any or all of these may be the key nutrient(s) limiting linear growth. If an intervention succeeds in increasing intake of some but not other key limiting nutrients, an impact on HAZ is unlikely. Secondly, in contexts where prevalence of infections (chronic and acute) is very high, improvements in diet may be insufficient to provide an impact on nutritional status. It is likely that recurrent infections negatively impact young child growth through increasing nutrient needs, decreasing appetite and intake, and/or increasing nutrient losses.

Since de-worming has been shown to have a significant impact on vitamin A absorption (Jalal, et al. 1998), serious consideration should be given to linking vitamin A food based initiatives to community or school-level de-worming programs. At the time the

TSNI study was conducted, Mozambique had no policy on prophylactic community-level de-worming and so no such linkage was possible. Malaria and diarrhea are two other major causes of illness among young children. While basic diarrhea prevention and control can be easily incorporated into most programs, as was done in the TSNI case, malaria prevention and treatment requires much more financial investment (particularly if bed nets are adopted as a component) and coordination with local health practitioners. Linking to health components or programs requires strategic thinking with key stakeholders on how to set up and operate such interventions given that agricultural calendars are frequently out-of-synch with schedules for other types of activities.

By the end of the two-year period, the TSNI approach created a demand for OFSP that exceeded supply. To a great extent, this is due to the selection of a drought prone area for intervention, as year-round production is difficult to achieve. However, the presence of excess demand and land encourages farmers to expand areas under production the following season. Expansion is only possible, however, if farmers have sufficient access to vines either from their own plots or elsewhere. Timely availability of adequate amounts of planting material emerges as the key constraint to sustained OFSP production in areas with 3-6 months of drought risk during the year.

The two most common methods of vine retention during the driest parts of the year are planting in valley bottoms with sufficient residual moisture to sustain the vines, and leaving some roots in the ground to re-sprout when the next rain comes. The drawback to the latter approach is that farmers typically have a limited amount of material emerging when the first rains comes, resulting in small plots of sweetpotato. Most households lacking sufficient planting material traditionally have obtained cuttings from their neighbors. However, two pilot experiences testing vine sales by local traders indicate that a willingness to pay does exist at key planting times in these areas suffering from a significant dry season.

When TSNI was designed, the common policy for sweetpotato vine distribution in Mozambique by SARRNET/INIA was to give planting material to farmers for free. This policy is derived from the classification of vegetatively propagated crops like sweetpotato as a public good, because no private sector seed company would want to engage in selling vines because farmers would not need to purchase annually, as is the case for hybrid maize seed, for instance. This model assumes, however, that farmers have access to appropriate land year round, and are able to maintain the quantity and quality of vines they need for the next season. Moreover, free material distribution by NGOs such as World Vision also has some unintended side effects. In some instances, agricultural extension agents reported that some farmers did not bother to protect and care for their vines after harvest with the expectation that the project would provide vines in the subsequent year.

Given that market demand exists for sweetpotato vines at key planting times, and paying for vines might increase the incentive for some farmers to better care for their planting material. The adoption of a decentralized, more commercialized system of vine multiplication and dissemination is recommended as a more sustainable approach than free distribution, and one that could potentially serve as an income generating activity for farmers engaging in sweetpotato vine multiplication.

Finally, during adaptive testing trials, several local varieties such as Canasumana were identified that have superior vine vigor under drought stress. These varieties should be crossed in Mozambique with the most popular prostrate, dark intensity OFSPs (Resisto, Cordner) to strengthen the adaptability to agro-ecological conditions in Zambézia. Implementation of this recommendation began in 2005 under SARRNET/INIA with the expectation that in five years OFSP material superior to existing clones in terms of drought resistance will be released. In the interim, the most promising new materials from the adaptive trials conducted during the past two years will be nominated for official release and distribution. These new OFSP varieties, along with five most popular released varieties being successfully deployed at the current time (Jonathan, LO-323, Resisto, CN-1448-49, and Japon), should continue to be promoted based on a modified TSNI integrated conceptual framework that incorporates the proposed commercially-oriented vine multiplication and dissemination strategy. This will assure the sustained cultivation and increased commercialization and diversified use of OFSP in drought-prone areas of Mozambique.

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