55 Assessing Nutritional Value and Changing Behaviours Regarding Orange-fleshed Sweetpotato Use in Sub-Saharan Africa

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Abstract
During the past 15 years, significant investments have been made in the development and promotion of orange-fleshed sweetpotato (OFSP) varieties in sub-Saharan Africa (SSA) due to their high β-carotene contents and thus, their potential to contribute towards reducing vitamin A deficiency. As the dominant varieties in SSA are white-fleshed, lacking in β-carotene, the introduction of OFSP means that producers and consumers need to accept the very visible change in colour along with any other trait differences.

We first review the building of the evidence base for OFSP in SSA, summarizing the key lessons learned to date, focusing on interventions aiming for impact on vitamin A intakes or status. Second, we review the state of knowledge concerning how to maximize the nutritional value of OFSP when processed and identify appropriate entry points to reach rural and urban consumers. Third, we explore how the health sector and private-sector marketing firms are tackling behavioural change and based on this accumulated multi-sector experience develop improved recommendations to guide practitioners on how they should approach reaching consumers. Finally, we pinpoint opportunities to enable the successful scaling out of OFSP adoption and utilization and identify areas of research needed to address remaining knowledge gaps.

In developing OFSP-focused food-based approaches, several key questions are addressed: (i) Are OFSP varieties competitive with existing local varieties?; (ii) Do producers and consumers accept a variety with a distinct colour difference?; (iii) What does it take to get proper utilization of OFSP at the household and the young child level?; (iv) What are the key nutrition messages?; and (v) What do we need to do to break into rural and urban markets?

We also examine the best techniques for assessing micronutrient contents of OFSP and its impact on status, the minimum amount of fat consumption linked to OFSP consumption and the bioaccessibility of OFSP processed in different ways. After reviewing how other sectors are approaching behavioural change, we propose 12 key recommendations on how to approach rural households and present dominant factors likely to influence urban consumer behaviour. The current policy environment is very favourable to integrated agriculture–nutrition interventions, and the Scaling Up Nutrition (SUN) movement emerges as the most promising opportunity for OFSP integration.

Keywords: behavioural change, beta-carotene, bioaccessibility, nutritional value, orange-fleshed sweetpotato (OFSP), scaling out, vitamin A

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55.1 Introduction

Overview of orange-fleshed sweetpotato (OFSP) benefits and introduction in sub-Saharan Africa (SSA)

The nutrition community has long recognized the negative impact of micronutrient deficiencies on the growth and development of children; the resultant economic cost of such deficiencies was recently estimated at 2.65% of gross domestic product (GDP) in Tanzania (Scaling Up Nutrition, 2013). Vitamin A deficiency (VAD) is widespread among young children on the African continent, with an estimated 36.4% of children under 5 years of age affected by VAD in 2007 (UN Standing Committee on Nutrition, 2011). VAD can limit growth, weaken immunity, cause xeropthalmia leading to blindness, and increase mortality (Sommer and West, 1996). Partners[1] in the Vitamin A Global Initiative, founded in 1997, are committed to the eradication of VAD as a public health concern.

Food-based approaches to combatting VAD aim to increase access to and intake of vitamin A-rich foods. There are two types of vitamin A available in foods: (i) highly bioavailable preformed retinol (vitamin A itself) typically found in animal foods such as eggs, liver and milk; and (ii) provitamin A carotenoids found in plant foods such as dark-green leafy vegetables and yellow and orange vegetables and fruits (McLaren and Frigg, 2001). Poor households typically cannot afford to consume animal foods on a regular basis. Among plant sources, β-carotene is the major provitamin A carotenoid and its bioavailability varies considerably. OFSP have good to excellent amounts of *trans*-β-carotene, which is highly bioavailable (Haskell *et al.*, 2004; van Jaarsveld *et al.*, 2005) and its true retention after boiling is high (70–92%) (van Jaarsveld *et al.*, 2006). Just 100–125 g of boiled or steamed OFSP available in SSA meet the daily recommended intake levels of vitamin A for children under 5 years of age (Low *et al.*, 2009). Moreover, unlike many vegetables, sweetpotato has significant amounts of energy (e.g. 76 kcal/100 g in sweetpotato versus 26 kcal/100 g in pumpkin) (USDA-ARS, 2011). Hence, OFSP is considered a **biofortified**[2] staple food crop that can tackle the problem of inadequate energy intake as well as VAD.

During the past 15 years, considerable research undertaken in Mozambique, Uganda, South Africa and Kenya has built the evidence base demonstrating that OFSP can be successfully introduced and is an effective tool for combatting VAD among children under 5 years of age (Hagenimana *et al.*, 1999; Faber *et al.*, 2006; Low *et al.*, 2007b; Hotz *et al.*, 2012a, b). Solid evidence for food-based approaches is considered to be limited (Ruel and Levin, 2000; Berti *et al.*, 2004; Masset *et al.*, 2011; Girard *et al.*, 2012). It is therefore important to understand how the evidence base for OFSP has been built to convince the nutrition community and policy makers of its potential, especially since the research on OFSP is being cited as one of the few well-documented food-based strategies demonstrating impact on vitamin A intakes and status (Masset *et al.*, 2011; Girard *et al.*, 2012). OFSP is the first biofortified crop to reach farmers' fields in SSA, and the lessons learned from this experience can potentially guide the design of other dissemination efforts of biofortified crops with a visible trait as well as inform other food-based efforts.

In spite of the practical experiences to date integrating agriculture and nutrition, our understanding of what actually makes individuals change their dietary behaviours is still very limited. In SSA, however, considerable investments in behavioural change research have been made with regards to tackling the human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) crisis, dietary practices, and water and sanitation access. Private-sector marketing firms also invest in understanding different consumer segments. Joining the experience with OFSP to date with that of these sectors could lead to an improved set of recommendations on how to maximize the uptake of OFSP and its potential health benefit.

Objectives of the chapter

There are four major objectives of this chapter:

1. Review the building of the evidence base for OFSP and summarize the key lessons

learned to date from its introduction in SSA, focusing on interventions aiming for impact on vitamin A intakes or status.
2. Review the current state of knowledge concerning how to maximize the nutritional value of OFSP when it is processed and examine what might be the most appropriate entry points to reach rural and urban consumers.
3. Explore how the health sector and private-sector marketing firms are tackling behavioural change and based on the combined experience to date develop improved recommendations to guide practitioners on how they should approach reaching rural consumers and urban consumers.
4. Pinpoint opportunities to enable the successful scaling out of OFSP adoption and utilization and identify areas of research needed to address remaining knowledge gaps.

55.2 Major Phases in the OFSP Story in SSA

Phase I: Confronting conventional wisdom (1995–2000)

Most dominant sweetpotato varieties in Africa or Asia are white or yellow fleshed. Prior to 1995, the attitude towards OFSP use in SSA by many scientists is captured in the major book on sweetpotato by Woolfe published in 1992: '*Sweet potato cultivars with deep yellow or orange-fleshed roots are unfortunately rejected in many developing countries in favour of white or cream-fleshed types having little or no pro-vitamin A activity*'. Attempts to introduce dark OFSP varieties in Bangladesh and other countries failed in the 1980s, not due to the colour but due to the moist texture (low dry matter content) of the varieties used. However, conventional wisdom reduced the message African and Asian consumers do not like orange-fleshed varieties.

In 1995, recognizing the seriousness of VAD in SSA, the International Potato Center (CIP) and the Kenya Agriculture Research Institute (KARI) began OFSP research as part of a broader effort to develop and test women-based approaches for addressing micronutrient deficiencies. In Kenya, sweetpotato production is largely under the control of women. The research compared OFSP uptake among women's groups receiving agricultural extension advice and the new OFSP varieties to women's groups receiving the same agricultural intervention *plus* nutrition education. The study found that nutrition education was essential for seeing an increase in the frequency of intake of vitamin A-rich foods among young children (Hagenimana *et al.*, 1999). Several OFSP varieties used in the study (selected from introduced varieties and local landraces) were found to yield as well or were superior to dominant local white- or yellow-fleshed varieties. Children were found to like OFSP varieties that were lower in dry matter content (more watery) than adults, who preferred higher dry matter content varieties similar to dominant existing varieties.

Breeding programmes began selecting for OFSP varieties with higher dry matter content. Small-scale OFSP development activities were funded in Uganda, other parts of Kenya and Tanzania, but the decade was notable for declining agricultural investment, and the nutrition community emphasized vitamin A capsule supplementation as the major strategy for combatting VAD.

Phase II: Building the evidence base (2001–2009)

While the agricultural community had begun to recognize the potential contribution of OFSP by the year 2000, the nutrition community to a large extent was not yet supportive, often citing lack of convincing evidence. An interest group spearheaded by CIP, the Vitamin A for Africa (VITAA) Platform, was created in 2001 to raise awareness and serve as a forum for exchange initially among five SSA countries. A 2001 *ex ante* study drawing on available data detailing where sweetpotato was produced and where VAD existed, estimated that switching from white-fleshed sweetpotato to OFSP could significantly contribute to reducing VAD in 50 million African children (Low *et al.*, 2001). Around the same time, a major

programme looking at breeding micronutrients across several staple crops, HarvestPlus, received significant funding and the term **biofortification** was coined. OFSP emerged at the forefront of the biofortification effort because very high levels of β-carotene already existed in the germplasm, and the breeding effort could focus on developing OFSP materials adapted to target areas in SSA and Asia. In other crops, the amount of the micronutrient within the crop had to first be increased to biologically significant levels.

An OFSP efficacy study conducted among school children (5–10 years old) in South Africa in 2002 measured vitamin A status using the modified-relative-dose response test (van Jaarsveld *et al.*, 2005). The treatment group (n = 90) consumed 125 g of boiled, mashed OFSP, while the control group (n = 90) ate white-fleshed sweetpotatoes for 53 school days. The treatment group showed significant improvement in vitamin A liver stores compared with the control group, with the proportion of children in the former group with normal vitamin A status increasing from 78% to 87% after the intervention. There was no significant change in vitamin A liver stores among the control group (86% to 82%). This evidence was bolstered by a community-level intervention in a very resource-poor area of Mozambique (the Towards Sustainable Nutrition Improvement (TSNI) project), where VAD prevalence among the children at the beginning of the study was 71%, using serum retinol concentrations as proxy for vitamin A status (Low *et al.*, 2007b).

The intervention consisted of an integrated approach along three intersecting pathways:

1. Agriculture: *Introduction of a new source of vitamin A and energy, using biofortified OFSP.* Intervention farmers organized in groups received planting material of high-yielding OFSP varieties, combined with lessons on how to improve crop management and storage practices to maximize the availability of OFSP throughout the year.
2. Nutrition: *Demand creation and empowerment through knowledge*. At the village level, principal caregivers, both women and men, were encouraged and enabled to improve infant and young child feeding practices, hygiene practices, and diversify the household diet. A nutrition extentionist conducted monthly group sessions for a year. Demand creation efforts focused on building awareness among the broader community to create: (i) demand for the new OFSP cultivars and derivatives; (ii) demand for other vitamin A-rich foods; and (iii) a supportive environment to accelerate behaviour change at the household level. These included provincial-wide radio programmes, community theatre performances, painted stalls and signs in local markets, and T-shirts, caps and sarongs worn by women decorated with the slogan '*O doce que dá saúde*' (the sweet that gives health).
3. Marketing: *Market development for OFSP roots and processed products.* This component aimed to link farmers to traders and to inform consumers about where they could purchase OFSP. Farmers with identified market outlets were more likely to expand the area under production. Thus, generated demand combined with market development stimulated production, enhanced producer income and spread the health benefits of OFSP to a wider population, all of which contributed to farmers' willingness to retain OFSP and expand production. Demand for OFSP was enhanced if profitable processed products using OFSP as a major ingredient were developed.

The intervention lasted 18 months in two of the poorest districts in rural Zambézia Province, Mozambique. World Vision, an international non-governmental organization (NGO), posted pairs of extensionists at the community level: one for agriculture and marketing, the other for nutrition. Each pair served 14 farmers' groups. In total there were 498 mother–child pairs captured in the study that were compared to 243 mother–child pairs from 'control' areas where no intervention was made.

By the end of the study, 90% of intervention households produced OFSP. Vitamin A intakes among intervention children (n = 498) were much higher than those of control children (n = 243) (median 426 versus 56 μg

retinol activity equivalents, $P < 0.001$). OFSP contributed 35% to the vitamin A intakes of all children in the intervention area and 90% among those who had consumed it the previous day. Controlling for infection/inflammation and other cofounders, a 15% decline in the prevalence of VAD was attributable to the integrated intervention (Low *et al.*, 2007b). OFSP was well accepted and liked by both adults and children.

Concurrently, interest in OFSP interventions began to grow and the VITAA Platform expanded to 11 SSA countries. The next important step was to investigate whether such an OFSP-led food-based integrated approach could be taken to scale at reasonable cost. Drawing on a modified version of the three pathways outlined above, simultaneous 2-year intervention studies conducted in Uganda and Mozambique as part of the Reaching End Users (REU) project tested two different levels of intensity of extension contact using extentionists supported by non-paid promoters recruited from the community (HarvestPlus, 2010). The intervention in Mozambique reached 14,000 households, while the intervention in Uganda reached 10,000 farmer-group-member households. A randomized, controlled effectiveness study evaluated the intervention's impact on the intake of OFSP and dietary vitamin A among children 6–35 months and 3–5 years of age and women in both countries (Hotz *et al.*, 2012a, b), and on the vitamin A status of the 3–5-year-old children and women in Uganda (Hotz *et al.*, 2012b). In Mozambique 77% of households adopted OFSP, compared to 65% in Uganda. In both countries, vitamin A intakes increased significantly among both women and young children, with OFSP contributing 78% of total dietary vitamin A intake among children 6–35 months of age in Mozambique and 53% in Uganda. Average costs per target beneficiary were US$86/household in Mozambique and US$56/household in Uganda. OFSP vines are easy for farmers to share. Hence with time, the initial investment had considerable spillover effects. In terms of just the vitamin A benefit (not considering the food security and other micronutrient benefits), the intervention in Uganda cost US$15–20 per disability-adjusted life year saved (HarvestPlus, 2010).[3] This amount falls within the 'highly cost-effective' category of interventions as defined by the World Health Organization (WHO).

Phase III: Addressing the bottlenecks to exploiting OFSP's full potential (2009 to date)

Building on growing donor support, CIP and over 30 partner organizations launched the 10 year Sweetpotato for Profit and Health Initiative (SPHI) in October 2009. The SPHI emerged from a 7 month consultative process to identify the constraints blocking the full exploitation of sweetpotato and develop interventions in breeding, propagation and dissemination of healthy planting material, crop management, human nutrition and marketing. The initiative's vision is to reposition sweetpotatoes in African food economies, particularly in expanding urban markets, to reduce child malnutrition and improve smallholder incomes. It seeks to positively affect the lives of 10 million African families by 2020 and is establishing support platforms in three sub-regions (East and Central Africa, Southern Africa, West Africa) to enable the creation of a vibrant community of practice. SPHI targets 17 countries and breeding or varietal selection activities are underway in 14 of those countries (Low, 2011). In addition to breeding, research has focused on addressing the problem of timely access by smallholders to adequate quantities of quality planting material and testing delivery systems that lead to enhanced vitamin A intakes and improved value chains for farmers.

The publishing of evidence and release of improved, more-adapted OFSP varieties in Mozambique and Uganda has led to substantial political and donor support in the dissemination of those materials. HarvestPlus continues to study going-to-scale with an integrated agriculture–nutrition strategy to reach 225,000 households by 2016; in Mozambique mass distribution of OFSP led by CIP to 122,000 additional households with a limited awareness campaign occurred in 2011–2013. Pressure is on to go-to-scale as cost-effectively as possible. Understanding

what the key components must be so that nutrition goals are still achieved is critical.

55.3 Key Lessons Learned

In developing OFSP-focused food-based approaches, several key questions had to be addressed:

1. Will the OFSP varieties be competitive with existing local varieties?
2. Are producers and consumers willing to accept a sweetpotato variety with a distinct colour difference?
3. What does it take to get proper utilization at the household level and the young child level?
4. What are the key nutrition messages that we must include?
5. What do we need to keep in mind if we want to have OFSP break into rural and urban markets?

Will the OFSP varieties be competitive with existing local varieties?

We learned that it was essential to cross locally adapted materials with orange-fleshed varieties to generate OFSP varieties with enough dry matter to appeal to adult tastes and with agronomic performance that was competitive with dominate local varieties. In drought-prone areas, it is essential to have varieties with vigorous vines, whose roots can re-sprout effectively if left unharvested. As of 2013, nine countries (Mozambique, Uganda, Rwanda, Kenya, Tanzania, South Africa, Zambia, Malawi and Nigeria) have released OFSP materials bred in the relevant country.

Are producers and consumers willing to accept a sweetpotato variety with a distinct colour difference?

The flesh of OFSP has a distinctive visual attribute (i.e. an orange colour because of the β-carotene content). The colour of the sweetpotato is directly related to the β-carotene content, and colour intensity (cream, yellow, yellow-orange, dark orange) may therefore be used as an indicator of provitamin A value (Takahata *et al.*, 1993). The vitamin A value of the sweetpotato is therefore visible to the consumer. In the TSNI project, the colour orange became clearly associated with healthy foods and proved to be an effective tool for demand creation and marketing. Consumers found the attractive golden colour of bread made with OFSP (replacing 38% of wheat flour with OFSP with medium orange intensity) superior to that of white bread (Low and van Jaarsveld, 2008), indicating that the visual trait is also beneficial in postharvest products. In Uganda, OFSP was particularly liked by children, and caregivers cited its orange colour as one of the reasons for the children's preference (Nagujja and Yanggen, 2005).

Associating colour in plant foods and health also occurs in more developed countries. Formal dietary guidelines often use a very simple message – eat a variety of different colours of vegetables and fruit. Australian women, who were not familiar with the β-carotene content of sweetpotato, considered OFSP to be healthy, purely based on the orange colour of the flesh. It was important for them to eat a variety of vegetable colours, of which yellow or orange was specifically referred to, and they valued OFSP as an easy way to add colour to meals (Henderson *et al.*, 2012).

The orange colour is not a barrier to adoption (Hotz *et al.*, 2012b), and building an 'orange brand' to raise awareness of vitamin A and OFSP as part of a marketing campaign can be very effective. For example, the orange colour can be used as a background for T-shirts, caps, sarongs, posters, market stalls, etc. that carry key messages associating OFSP and good health. However, one challenge in many SSA countries is that local languages have no specific word for orange and there is often confusion among users between yellow and orange. Since the yellow colour in sweetpotato is often partially caused by other carotenoids, the amount of β-carotene can be limited. Hence, special attention must be paid to eliminate this common confusion.

What does it take to get proper utilization at the household level and the young child level?

A key concern of planners and practitioners is understanding what kinds of investments are essential for achieving impact and how can the cost of an intervention be as low as possible, yet effective. The TSNI and REU projects described above, along with work in Kenya are the basis of the key lessons learned about what it takes to get adoption and utilization of OFSP at the household level and what it takes to actually make an impact on young child nutritional status. In the REU project, the two selected countries were highly contrasting: Uganda had better growing conditions for sweetpotato, higher population densities (hence, lower service delivery costs), better educated pools of extension personnel, and more highly educated farmers than Mozambique. In the TSNI project, which was only in Mozambique, two extensionists (one for agriculture and marketing, one for nutrition) per site were responsible for all farmer training and follow up; in the follow-up REU project, extensionists worked with village-level nonpaid promoters, who were provided with job tools and promotional clothing. The agriculture and health promoters, in turn, taught fellow farmers with backstopping from the extension personnel.

Some key lessons learned from our experience to date are summarized below.

1. *If the goal is to improve young child vitamin A intake, investment in community-level nutrition education is needed.* If farmers like the introduced OFSP variety's agronomic performance and taste, it will be adopted and utilized as part of the family diet. However, to make an impact on young child vitamin A status, particularly the very vulnerable 6–18 month olds, use of OFSP-based complementary foods (e.g. porridges) and increase in feeding frequency are critical and most effectively delivered through community-level approaches.

2. *Designing the project intervention from the beginning with a gender perspective in mind is key*. From the outset, project designers realized: (i) the importance of recruiting both women and men as extentionists and promoters; and (ii) that men influence the land allocated for sweetpotato, what foods are consumed within the household and can enhance or deter the adoption of improved care-giving practices of other members. Data from Mozambique show that female nutrition extension workers were significantly more successful than male nutrition extension workers in teaching messages about child feeding and vitamin A to nutrition promoters. However, in rural settings, male extension personnel typically outnumber female extension personnel. When male nutrition personnel are employed, it is important to give them extra training on how to conduct cooking demonstrations and interact with women effectively about breastfeeding.

3. *In addition to the agriculture intervention, it is necessary to have regular interaction with caregivers with young children in nutrition-focused groups with repetition of consistent messages alongside demonstrations to ensure OFSP uptake and incorporation into the young child's diet as well as the household diet.* Extension personnel working with groups (each having 15–30 members with young children) can effectively achieve uptake and incorporation of OFSP in to the household diet and the young child's diet and overall nutritional knowledge can be improved by holding monthly meetings with caregivers, assuming the extension personnel are properly trained and equipped with appropriate tools and skills. In the TSNI project, findings showed that six additional home visits did not lead to any better use of OFSP and other vitamin A-rich foods, but there was more use of other vegetables and fruits and fat in the diet among groups receiving additional home visits. In the REU project, having a second year of nutritional lessons, often repeating first-year messages, did not result in any greater adoption or better utilization of OFSP by young children. If it is difficult to get fathers to attend nutrition sessions, consider holding separate sessions for men or incorporate key nutrition messages into agricultural/marketing training that they attend.

4. *Extension personnel need quality job aids.* Formative research is needed in each country setting to tailor messages to the education level of the target population and produce written and promotional materials in local languages whenever possible. Clearly, utilization of existing, approved nutrition messaging from government makes sense. Demonstrations (especially for recipe preparation) were the preferred method of transmitting knowledge to farmers. Effective job tools to accompany participatory learning sessions can include: (i) portable-designed flipcharts or laminated A4 cards with key pictures and messages on the front and instructions on the back to remind extentionists about how to best conduct the lesson; (ii) an agricultural calendar describing key crop management tasks to be done each month; and (iii) simple recipe books. Having groups write and sing songs about OFSP and how to use it is an effective way to reinforce key messages.

5. *The total number and depth and frequency of training extension personnel and community promoters/volunteers are dependent on the level of formal education of the pool of candidates.* For example, most extentionists in Uganda were college graduates, whereas most extentionists in Mozambique had completed just 2 years of secondary school. Most community volunteers in Uganda had completed primary school, as had male promoters in Mozambique, but the vast majority of female nutrition promoters in Mozambique were practically illiterate. Personnel with higher levels of formal education are able to absorb a wider range of knowledge and retain and transmit it more effectively than those with substantially less education. In Uganda, single extension agents worked on agriculture, nutrition, and marketing modules. In Mozambique, the project had separate extension personnel for agriculture and nutrition and a university graduate coordinated the marketing work. When educational levels are low, frequent refresher training is required for extension personnel. In Mozambique, these refresher sessions were aligned with monthly staff meetings scheduled when personnel came for their monthly salary payment. In Uganda, extension staff members were trained at the beginning of every season and expected to write weekly progress reports.

6. *In some settings, it will be possible to save costs by using existing farmer or social groups as an entry point.* In the TSNI project, considerable time was spent working with communities to establish farmer groups. In the REU project, to lower costs, existing farmer and church groups were used as entry points. The advantage is that the core members already know and trust each other. The main drawback to working with existing groups is that often an insufficient number of members are households with young children and hence the group size has to expand. Other projects are using antenatal clinics as entry points for recruiting pregnant women to participate in clubs where nutrition education and OFSP utilization are the focus.

Many projects, like the REU, included the use of village resident promoters/volunteers as a way to reach more direct beneficiaries at a lower cost. Criteria are established for the community to select the person that will be trained as an agriculture or nutrition promoter. Some argue that an advantage of using promoters is that people are more likely to adopt something promoted by their peers than by an outsider. Since farmers' groups often meet at weekends, promoters have an advantage over extension services that only work weekdays.

In using community-level promoters/volunteers, the following lessons have been learned:

1. *Use of volunteer promoters is not cost free.* To be effective and remain motivated, incentives for community volunteers are a critical part of any programme and need to be adequately budgeted for. These typically include job tools and attire (badges, T-shirts, hats, decorated sarong) and even bicycles. Promoters require initial training, retraining and monitoring. Staggering the provision of incentives helps to periodically re-motivate promoters. Most promoters are effective for a maximum of 2 years and typically can only be involved a limited number of days per month.

2. *Be aware of government policy and practices of other organizations.* Dissatisfaction among promoters is likely to be high if other organizations are offering better 'incentives'. Some SSA governments are now advocating standardized packages/practices for organizations utilizing community-level workers/promoters. Other projects have found it very effective to pay promoters a small salary each month.

3. *It is critical to monitor the accuracy of the promoters training of caregivers.* While nutrition promoters were able to achieve the desired impact, REU findings clearly demonstrate that for extension personnel accurate knowledge retention was higher than that of the nutrition promoters, and the nutrition promoters in turn showed higher message retention than the mothers they taught. The latter was due to: (i) receiving better training (from extentionists); (ii) receiving regular message 'recaps' from extentionists in their training; (iii) physically possessing job aids (as a memory jog); and (iv) being required to train other people, which thus solidified their own knowledge.

Since the end of the REU project, we have seen in some countries the rapid spread of cell phone uptake in rural areas. This could potentially revolutionize the ability to engage in repeat messaging and monitoring of community-level activities in addition to empowering caregivers to actively seek knowledge on a demand basis. This should further lower the cost of going-to-scale of the integrated approach.

What are the essential messages to include in a nutrition component?

Experience in implementing programmes in Uganda and Mozambique has demonstrated that the topline nutrition message to be communicated to the target population is primarily about the linkage between OFSP and vitamin A. The success of this topline message is, however, partially dependent on the existence of a vitamin A supplementation (VAS) programme being implemented by the Ministry of Health in the country. VAS programmes do exist in most developing countries and the communication messages are often linked to child or family health days that are being promoted by the respective government. Where these communication programmes exist, parents are instructed to bring their children under the age of 5 years for immunization, including VAS, at the nearest health clinic or centre twice per year. As a result, many mothers are familiar with the term 'vitamin A' and they know that their child should take it as part of the immunization package. Consequently the link between vitamin A and OFSP is a natural one and becomes the first message to be delivered to farmers and mothers alike – 'OFSP has vitamin A. Vitamin A is good for your health'. The specifics of how vitamin A improves health become the supporting messages for the topline nutrition message. Thus the supporting messages about vitamin A are that children need it for good health, to fight common infections and to maintain normal vision.

OFSP should not be considered a 'silver bullet' solution to VAD and neither should it be presented as one to the recipient populations. Child health is affected by many more factors than just vitamin A and situating a vitamin A intervention such as OFSP within the larger context should be considered if the child is to benefit from the increased vitamin A being delivered through OFSP. Children with VAD often live in situations where there is a dearth of quality health care services and nutritional information available to parents and/or caregivers. Basic infrastructure including safe water sources and waste disposal are often lacking and these combine to work against good child health practices. As a result, it becomes imperative to consider which other supporting nutrition messages are required by the recipient populations so that the intervention of OFSP is maximally supported. Telling parents to feed their children OFSP can be detrimental if the parents do not understand that exclusive breastfeeding should be practised from birth until 6 months of age, after which foods such as OFSP can be introduced. Mothers must also understand that their own nutrition will affect the nutrition of their babies.

Consequently, there is a set of additional essential messages that must be considered so that OFSP/vitamin A messages are set within an appropriate context. These messages can be considered as supporting messages insofar as they provide the check-and-balance that helps prevent parents and caregivers from taking the OFSP/vitamin A messages out of context. In our experience, we have learned that the specific messages that most caregivers do understand include:

- *Breastfeeding:* Parents are taught that babies should be exclusively breastfed from birth to 6 months and that breastfeeding should continue until the age of 2 years. Caregivers are taught that vitamin A is transmitted from mother to baby via breast milk hence it is important that the breastfeeding mother is consuming enough food which contains vitamin A. The importance of giving the infant the first milk (**colostrum**) in most cases is an easy practice for mothers to adopt; however, preventing the provision of herbal drinks or water as part of traditional ceremonies during the first weeks of life has proved challenging.
- *Young child feeding:* Parents and caregivers are taught about which foods can be introduced to children after 6 months and how to prepare them so that the child will eat enough. Frequency of feeding, food combinations and feeding of sick children is also addressed. Increased feeding frequency is often achievable, with OFSP being used as a breakfast food or snack significantly contributing to its achievement. Cooking demonstrations, where OFSP is combined with other locally available food sources, are more effective than lectures because they are interactive and participatory.
- *Balanced diet and vitamin A-rich foods:* Using/adapting the food guide being promoted by the respective Ministry of Health, mothers and caregivers can be taught about how different foods are necessary for functions within the body. They can learn how to combine them and prepare them to improve family diets. In this case it is imperative to use foods that are available to the population. Particular attention is paid to the sources of vitamin A – both animal and plant sources, including the OFSP and sources of fat. Most nutrition projects do not include much detail about food sources of vitamin A and tend to recommend VAS.
- *Hygiene, sanitation and safe water:* It has been well documented that diarrhoeal diseases are one of the top causes of mortality and morbidity among young children thus any gains that are made with increasing vitamin A intakes through the diet (i.e. OFSP) are diminished if hygiene, sanitation and safe water issues are not addressed in households. Safe water sources are still lacking for millions of households, and basic hygiene and sanitation facilities are beyond the reach of many yet with simple practices it is possible to break the major transmission routes. In our experience, while these messages are important, they have proved very difficult to change without a fairly intensive education strategy and sufficient financial and technical resources to address this component. Hence, some OFSP programmes concentrate their resources on the nutrition/agriculture messages and not on these topics.

In deciding which messages are likely to result in behaviour change, the Trials for Improved Practices (TIPs) approach is highly recommended and a step-by-step guide is available for practitioners (Dickin *et al.*, 1997). It involves conducting consultative research with mothers of different socio-economic status or cultural backgrounds to identify simple and effective actions within the household that will improve child feeding and then test these recommended practices in homes with caregivers to determine which are the most practical and culturally acceptable. Those that work are then promoted at the group level.

OFSP becomes the *entry point* to address family diets and child feeding (Low

et al., 2007a). As a result this intervention can be added to existing programmes which are providing additional supportive activities, such as growth monitoring. Mothers, caregivers and communities can be empowered to make changes and an enabling environment will allow for the uptake of the crop and the messages.

What do we need to keep in mind in order to have OFSP break into rural and urban markets?

Having markets for roots drives sweetpotato farmers to expand and sustain OFSP production. General awareness campaigns to reach potential OFSP producers and caregivers, especially those using songs on the radio, concurrently contribute towards building market demand for OFSP roots. The REU project again provided an opportunity to study two very different sets of conditions: (i) breaking into well-established, larger sweetpotato markets in a country (Uganda) where sweetpotato is a primary staple and there are strong consumer preferences for existing non-OFSP varieties; and (ii) breaking into a smaller and seasonal sweetpotato market in a country (Mozambique) where sweetpotato is a secondary staple and poorer consumers are more price conscious than variety conscious. Clearly, marketing is a complex target, requiring knowledgeable personnel for implementation. A project should be at least 3 years and preferably 5 years long to have a marketing component as it takes time to build up sufficient production for a meaningful effort.

Overarching lessons learned about breaking into markets include:

1. *Understand the existing sweetpotato marketing chains and relative price of sweetpotato compared to other food staples and foods rich in vitamin A as an input into the design of a marketing strategy.* Sweetpotato varieties are unique to each country and consumer behaviour varies based on: (i) whether sweetpotato is a staple food or is viewed as a vegetable or snack; (ii) what crops it competes against; (iii) how it is marketed and its relative prices; (iv) whether significant areas already exist with commercialized sweetpotato growers; and (v) whether and how women are engaged in trading sweetpotato.

2. *Health messages linked to the orange colour is the demand-pull for OFSP.* The link to the benefits of vitamin A and the high amount of provitamin A in OFSP is the key message for all areas. In urban zones, upper end consumers are increasingly concerned about diabetes and the good dietary fibre content of sweetpotato peels should also be stressed in this regard (Bovell-Benjamin, 2010). Use of radio and promotional jingles has been very successful in building urban market demand for OFSP.

3. *Every country has a unique set of sweetpotato varieties and it is important to understand the preferences of different sub-groups (young children, women, men, youth and agro-processors).* Invest in consumer surveys and training a sensory panel to evaluate different varieties. Make sure each variety has a market-friendly name and assess its suitability for different uses (boiled, chipped, crisped, bakery products). Unfortunately, there is a tendency to lump OFSP varieties with the same skin colour into a common category. Investing in labelling and creating consumer awareness about the uniqueness of each variety will facilitate monitoring the growth of OFSP commercialization.

4. *Facilitate linking traders to farmers and traders to market opportunities.* It is difficult to break into strong, existing sweetpotato market chains where traders have an understanding of existing consumer preferences and certain traders control access to key wholesale markets in urban centres. However, to facilitate links the following should be considered: (i) hosting a meeting between traders and growers; (ii) encouraging contractual commitments between traders and farmers; and (iii) subsidizing painting of market stalls and providing decorated umbrellas and aprons. Specialized marketing organizations can facilitate linking traders to credit opportunities, as farmers prefer being paid up front for their roots.

5. *Train and treat retail traders as change agents, capable of spreading nutritional messages, and stress separating OFSP from*

other non-OFSP type varieties at point of sale. Experience has shown that when there are media promotion activities and OFSP is sold separately from other sweetpotato types, either a premium price (up to 15% higher than white-fleshed) for OFSP emerges, or traders note that OFSP sells faster, even when it is selling at the same price.

6. *Even if economically viable opportunities for OFSP-based product development emerge, the major commercialized product during the next 5 years will remain roots.* Investing in appropriate harvest and post-harvest handling methods and fresh root storage to avoid market gluts should be considered. Sweetpotato supply chains tend to be short because of the bulkiness of the crop, so initiate market activities in areas with good access to major trade routes.

7. *Since smallholder farmers typically prioritize home consumption before sales of food crops, including some larger, commercially oriented sweetpotato farmers from the outset helps assure consistent supply.* The most difficult challenge in all marketing projects has been stabilizing root supply throughout the year. This is critical for OFSP processed product development.

In marketing campaigns in Rwanda, efforts to break into the urban market have focused on attracting youth through hiring a young IT specialist to use social media (Twitter, Facebook, etc.) to promote consumption of the OFSP among urban youth. In Bukedea district (Uganda), where sweetpotatoes were not widely consumed at the start of the project, a whole new trading system sprang up based on young, male bicycle traders who assembled OFSP from project growers and took it to more distant markets.

55.4 Reflections on the Current State of Knowledge and Remaining Gaps Concerning Nutritional Value

Clearly to make a difference, OFSP varieties or products being promoted need to have the desired nutritional quality and the amount of provitamin A (β-carotene) is the key micronutrient of interest. Moreover, we need to be able to evaluate impact of OFSP consumption on vitamin A status. In this section, we will identify advances in knowledge concerning nutritional values and assessment and pinpoint remaining gaps.

Best techniques for assessing micronutrient content of OFSP and its impact on status under laboratory versus field conditions

Evaluating OFSP nutritional content

As mentioned above, intensity of orange colouring is highly correlated with β-carotene content in sweetpotato. Detailed field charts have been developed for use by breeders in the field that include approximate β-carotene content.

Due to the inherent difficulties in carotenoid analysis such as incorrect quantification by various analytical methods available, as well as improper sampling and sample preparation, the reliability and/or validity of the values reported for this important micronutrient in the available literature is often questioned (Rodriguez-Amaya, 1997). In fact, errors incurred in sampling can easily surpass those from the analysis itself (Gross, 1991; Rodriguez-Amaya, 1993). It is also important to include in the results the variety of the OFSP, the maturity stage, the portion size analysed as well as the season and geographical origin (Gross, 1991; Rodriguez-Amaya, 1993).

Laboratory assessment of β-carotene contents of OFSP is best achieved by chromatographic separations, with high performance liquid chromatography (HPLC) being the most appropriate and widely used. The main problems in HPLC include obtaining and maintaining carotenoid standards for quantification, and the extremely high capital, maintenance and operational costs required. Thus, most studies using HPLC in developing countries are usually supported by external funding (Rodriguez-Amaya, 1997).

Fortunately, during the past decade, much work has gone into developing the correct calibration curves between HPLC or other wet chemistry standards and readings

from near infrared reflectance spectroscopy (NIRS). Zum Felde *et al.* (2009) have developed a fast-throughput system for sweetpotato using NIRS, that can analyse raw root samples for protein, sugars and major micronutrients, including β-carotene, and minerals in a few minutes. This has revolutionized the ability to engage in breeding for quality traits in sweetpotatoes cost-effectively. A remaining gap is to develop similar calibration curves for cooked roots.

Techniques for assessing vitamin A status in the field

Studies seeking to identify VAD populations or evaluate the effectiveness of an intervention need to select appropriate biomarkers. Tanumihardjo (2011) describes how each marker performs and its suitability for assessing vitamin A status across the continuum from deficient to adequate to toxic. In SSA, most studies are concerned with measuring subclinical levels of vitamin A depletion, when liver reserves are marginal. In field studies, serum retinol concentrations are the most common indicator used. In addition, methods have been developed that are less expensive that use surrogate analyses for the carrier protein retinol-binding protein (RBP). However, both serum retinol and RBP concentrations are static measures and do not always change in response to an intervention (Tanumihardjo, 2011). It is important to measure and control for infection and inflammation and detection of change is more likely when working with a population with high initial levels of VAD.

For lactating women, breast-milk retinol concentrations can be used as an indicator of vitamin A status, with potential extrapolation to the breastfeeding infant (Tanumihardjo and Penniston, 2002). However, it may be more indicative of recent dietary intake as opposed to status.

Currently, the two best methods for assessing vitamin A status are the dose–response test and the isotope dilution test, both of which require laboratory settings for data collection. The modified relative-dose–response test (MRDR) is very useful for evaluating a deficient-through-normal vitamin A status and requires one blood sample from each subject. Tanumihardjo cites several examples where MRDR detected significant differences between two populations when the serum retinol test did not. The isotope dilution test is the most sensitive biomarker of vitamin A status of liver reserves, but also the most expensive. Hence, this method is rarely used for programme evaluation, although consideration could be given to applying it in a randomly selected sub-sample as was done for children participating in a sugar-fortification programme in Nicaragua (Ribaya-Mercado *et al.*, 2004).

Clearly, there is a need for more accurate field-suitable methods than serum retinol or RBP concentrations. Until this is available, it is critical to have vitamin A intake indicators to help build the chain of evidence along the impact pathway of the intervention.

What is the minimum amount of fat consumption linked to OFSP root consumption in terms of timing and quantity and the bioaccessibility of OFSP when fat availability is extremely limited?

The bioaccessibility and bioavailability of a nutrient are governed by the physical properties of the food matrix, which affect the efficiency of the physical, enzymatic and chemical digestion processes (Parada and Aguilera, 2007). It is well understood that the co-consumption of dietary fat is required for the best absorption of carotenoids from a meal. The release of nutrients from the food matrix during digestion makes them **bioaccessible** and fat is essential for the process of miscellarization, as well as the presence of bile salts, during which carotenoids are emulsified and solubilized for absorption by the intestine's enterocytes (Olson, 1994) making them **bioavailable**.

Carotenoid absorption from a meal containing β-carotene sources is enhanced with increasing amounts of dietary fat or food

with a high fat content (e.g. avocado fruit) (Jalal *et al.*, 1998; Brown *et al.*, 2004; Unlu *et al.*, 2005). The absorption of carotenoids, including β-carotene, is negligible after ingestion of fresh vegetable salads with fat-free salad dressing (Brown *et al.*, 2004). Over and above the importance and the amount of dietary fat, the type of fat also affects postprandial carotenoid concentrations. The absorption of β-carotene is significantly enhanced with co-ingestion of long-chain fatty acyl groups compared with medium-chain fatty acyl groups (Borel *et al.*, 1998), whereas the degree of unsaturation of the fatty acyl groups has no effect on the *in vitro* bioaccessibility of carotenoids (Huo *et al.*, 2007). In Mongolian gerbils, bioconversion of provitamin A carotenoids from sweetpotato was improved as the amount of fat in the diet increased from 3% to 12% (Mills *et al.*, 2009).

Studies using different food matrixes as sources of β-carotene, for example a root crop such as sweetpotato (Jalal *et al.*, 1998), carotenoid-enriched spread (Roodenburg *et al.*, 2000), or green leafy vegetable such as spinach (Jayarajan *et al.*, 1980), suggest that a minimum amount of between 3 g (Jalal *et al.*, 1998; Roodenburg *et al.*, 2000) and 5 g (Jayarajan *et al.*, 1980) fat per meal is required to ensure intestinal carotenoid uptake. Food-based interventions should therefore incorporate recommendations to add this minimum amount of fat to the meal containing OFSP in order to improve vitamin A status of at-risk populations. In very poor rural environments, with few sources of fat in the diet, consideration may need to be given to introducing a fat-rich food source, such as avocado or groundnut, concurrent with the introduction of OFSP.

What are the OFSP processed products that have the best nutritional value and highest potential adoption and impact on those most at risk of VAD in urban versus rural communities?

'Natural' food structures remain at the cornerstone of influencing the bioavailability of carotenoids and other nutrients. Food processing improves bioavailability by disrupting cell walls of plant tissues, dissociation of the nutrient-matrix complexes, or transformation into more active molecular structures. Carotenoids present in plants are partially concentrated in chromoplasts or chloroplasts. Therefore the extent of release from these food matrices is highly variable and will depend on whether carotenoids are non-covalently bound to protein or fibre or dissolved in oil or in crystalline form (Parada and Aguilera, 2007).

During the past decade, considerable research has been done on retention of β-carotene in OFSP when processed and cooked. Retention is influenced by: (i) the cultivar; (ii) the cooking process used (temperature and oxygen exposure, in particular); and (iii) the duration of cooking. Almost all β-carotene in raw OFSP is in the available *trans*-configuration and the degree of isomerization to the less available *cis*-configuration during processing is thus also important. Boy and Miloff (2009) summarized findings from 20 studies that met stated quality standards for seven processing techniques: boiling, steaming, frying, roasting, microwaving, baking and drying. Boiling, the most common and affordable form of preparation in SSA, has one of the highest retention rates (84%, range 50–130%) among the techniques studied. Retention was also high for steaming (77%, range 48–95%) and frying (79%, range 67–95%). Roasting whole sweetpotato on a grill showed higher retention (74%; range 40–100%) than baking (69%). Numerous drying techniques in both dry and wet weather yielded β-carotene retention results above 50%. Oven-dried sweetpotato retained on average 87% β-carotene content (range 79–96%). Overall, *cis*-isomer levels were minimal, except for baking and microwaving.

Heat exposure during processing increases bioaccessibility by disrupting cell walls and breaking up the protein complexes in which the β-carotene is embedded. Tumuhimbise *et al.* (2009) studied the effect of traditional heat processing methods on the microstructure and *in vitro* bioaccessibility of β-carotene among OFSP varieties currently in use in Uganda (Table 55.1). They

Table 55.1 Effect of processing methods on the amount of *trans*-β-carotene, bioaccessible *trans*-β-carotene and the estimated bioaccessible retinol activity equivalents (RAE) in three varieties of orange-fleshed sweepotato used in Uganda.

	Variety								
	Ejumula			Kabode (Naspot 10/SPK 4/6/6)			Kakamega (SPK004)		
Flesh colour	Dark orange			Medium orange			Light orange		
Columns[a]	a	b	c	d	e	f	h	i	j
Form[b]	All *trans*-β-carotene (µg/g dm)	Bioaccessible *trans*-β-carotene (µg/g dm)	Estimated bioaccessible RAE (µg/100 g fw)[c]	All *trans*-β-carotene (µg/g dm)	Bioaccessible *trans*-β-carotene (µg/g dm)	Estimated bioaccessible RAE (µg/100 g fw)[c]	All *trans*-β-carotene (µg/g dm)	Bioaccessible *trans*-β-carotene (µg/g dm)	Estimated bioaccessible RAE (µg/100 g fw)[c]
Raw	314.5	34.8	174	212.4	41.5	194	100.6	18.2	85
Boiled (20 min at 92°C)	248.5	106.5	530	153.4	70.7	330	64.8	37.2	174
Steamed (30 min at 94°C)	246.9	105.8	529	157.0	64.6	302	59.6	25.3	118
Deep fried slices (10 min at 170°C)	259.8	150.8	750	169.8	101.1	472	64	40.5	189
Baked (15 min in 108°C)	229.7	78.3	390	127.0	48	224	50.7	18.5	87

[a]Results reported in columns a, b, d, e, h and i are adapted from Tumuhimbise *et al*. (2009). For details on standard deviations, consult the article.

[b]The amount of 'all *trans*-β-carotene' and bioaccessible *trans*-β-carotene (measured in µg/g dry matter (dm)) in the micellar fraction was determined by high performance liquid chromatography (HPLC). The values are means based on three samples of each preparation type.

[c]Estimated bioaccessible RAE (measured in µg/100 g fresh weight (fw)) was calculated by multiplying the bioaccessible *trans*-β-carotene value by the dry matter proportion (0.30 for Ejumula, 0.28 for Kabode and Kakamega) and adjusting for the amount in 100 g, and then using a bioconversion factor of 6 units β-carotene to 1 unit retinol because bioaccessibility has already been accounted for.

showed that the bioaccessibility of β-carotene differed due to processing technique. Bioaccessibility of β-carotene increased from raw, to baking, to steaming/boiling, to deep frying. The β-carotene in deep-fried OFSP was more bioaccessible than that in OFSP prepared by other processing procedures, indicating that fat increases bioaccessibility. Therefore, although heat processing reduces β-carotene retention, the loss in retention is compensated for by improved bioaccessibility because of the presence of fat.

It is best to use OFSP varieties of at least medium orange intensity in nutrition programmes, at least 55 µg/g of β-carotene on a fresh weight basis (fwb). Moreover, indications are that for a given OFSP variety, fried products will provide more provitamin A per 100 g than baked products. However, the heavy fat content of fried products means that they should not be promoted as healthy foods. For young children, the best product would be boiled and mashed sweetpotato with at least 3–5 g of fat added and ideally a good protein source.

Bechoff *et al.* (2011) investigated retention and bioaccessibility of three products, fried doughnuts (mandazi), chapatti (flat bread) and porridge, made with 30% sweetpotato flour by local agro-processors. They found that the efficiency of miscellarization of all-*trans*-β-carotene and bioaccessibility was greater in the fried products (chapattis and mandazis) than that in the boiled products (porridge and purée). Taking bioaccessibility into account alters the amount needed of a product to meet the recommended dietary allowances. For example, an individual would need to eat either 220 g of OFSP purée or 100 g of OFSP chapatti to get the equivalent amount of vitamin A (Table 55.2). However, if a little bit of oil was added to the boiled OFSP purée, no doubt the bioaccessibility would increase significantly. As more products emerge on the market, there will be need for bioaccessibility assessments, not just retention studies.

One constraint to product development has been the relatively high price of sweetpotato flour compared with wheat flour. It takes 4–5 kg of fresh sweetpotato to make 1 kg of flour. In most SSA countries sweetpotato flour is as expensive as wheat flour. Hence, there has been more interest in using sweetpotato purée (boiled and mashed) for wheat flour substitution in bakery products as it takes only 1.25 kg of fresh root to make 1 kg of purée. In Rwanda, 45% of wheat flour is replaced with OFSP purée in a 'Golden Power' biscuit.

A major challenge in using sweetpotato purée compared with flour is that it is difficult to store. In the USA, sweetpotato purée is most often marketed in pails or drums that must remain frozen or chilled until use. There is, however, an advanced method for rapid sterilization and aseptic packaging of OFSP purées using a continuous flow microwave system in use in the USA (Coronel *et al.*, 2005). The product is packaged in flexible plastic containers or aluminum-polyethylene laminated bags, demonstrating shelf stability for 12 months and high retention of β-carotene.

There is an urgent need for a more affordable way than the microwave system of storing OFSP purée without refrigeration, but retaining high levels of β-carotene. Scant information is available on this because it is a relatively recent topic. Techniques using vacuum frying with carrots could potentially be applied to sweetpotato (Dueik *et al.*, 2010). It has been shown that vacuum frying can reduce oil content by nearly 50% and preserve approximately 90% of *trans*-α-carotene and 86% of *trans*-β-carotene in carrots. Exclusion of oxygen (e.g. through vacuum or hot filling, oxygen-impermeable packaging, inert atmosphere), protection from light and low temperature diminish carotenoid degeneration during storage (Rodriguez-Amaya and Kimura, 2004). This is a priority for future research.

Should we be investing more in promoting leaf consumption?

To date, OFSP promotion efforts in SSA have focused principally on roots. However, in many African countries (e.g. Zambia, Sierra Leone, Liberia and Angola) sweetpotato leaves are widely consumed and often have

Table 55.2. Amount of all *trans*-β-carotene in different OFSP products (variety Ejumula). (From Bechoff *et al*., 2011, p. 10378 with permission.)

OFSP product	Fat (%)	All *trans*-β-carotene (µg/g)	All *trans*-β-carotene bioaccessibility (µg/g)	Unit	After *in vitro* digestion: µg retinol equivalent per unit shown in the previous column
Boiled OFSP	0	95.0 ± 2.0	9.9 ± 0.1	Purée portion (100 g)	183.7
Porridge (30% OFSP flour)[a]	0	8.7 ± 0.3	16.3 ± 0.9	One mug (300 g)	80.0
Chapatti (30% OFSP flour)[a]	7.4	31.5 ± 1.4	72.7 ± 5.4	One chapatti (100 g)	401.7
Mandazi (30% OFSP flour)[a]	3.3	32.9 ± 1.7	49.0 ± 3.0	Two mandazi (90 g)	289.6

[a]Porridge, chapatti and mandazi all contained 30% OFSP flour made from the Ejumula variety.

value as a cash crop in peri-urban/urban settings because they can be ratooned for a long period. In East Africa, the higher protein content of sweetpotato leaves (16.0% crude protein) compared with Napier grass (10% crude protein) is appreciated in the dairy industry (Lukuyu *et al.*, 2012).

Sweetpotato leaves have moderate amounts of β-carotene after cooking (550 µg/100 g), but the bioavailability of that β-carotene has still not yet been determined. The leaves are also a rich source of dietary lutein (which can delay macular degeneration), having higher levels than other cruciferous leafy vegetables (Menelaou *et al.*, 2006). Levels of polyphenolics, namely anthocyanins and phenolic acids, are also high compared with major commercial vegetables; polyphenolics protect against diseases linked to oxidation such as cancer, allergies and cardiovascular disease (Islam, 2006). The stems and leaves of sweetpotato also contain chlorogenic acids, which have been shown to improve glucose tolerance in humans (Bovell-Benjamin, 2010). Clearly further research work is needed on the functional properties and application potential of isolated bioactive compounds from sweetpotato leaves. Given the nutritious nature of the leaves, increased promotion of their use for human consumption is warranted.

55.5 Reflections on the Current State of Knowledge and Remaining Gaps Concerning Behavioural Change

What can we learn from other behavioural change efforts in health (HIV/water sanitation) that could help us develop a lens for behaviour change for an integrated agriculture–nutrition project?

The field of behaviour change has developed and expanded substantially in the past 30 years in part because of the global AIDS pandemic which has required us to re-examine our understanding of how much we really know about changing behaviours. Since that time the water and sanitation sector (WATSAN) has faced their own limited success in improving the situation in the world despite massive infrastructural interventions and they too have realized that a deep understanding of human behaviour is called for if the investment in infrastructure is to be properly valued. The valuable lessons learned about behaviour change through AIDS and WATSAN can now be applied to the agriculture and nutrition sectors in particular as these two sectors now strive to integrate their efforts in projects that make a difference. Key to these lessons is the understanding that people interpret and at times create new meanings of information based on their own context; culture, norms and surrounding influencing social networks. People can't always control the issues that create their behaviour and, moreover, people are not always rational in deciding what is best for their health and well-being (Communication-Change, year unknown). Social and behaviour change communication (SBCC) uses the socio-ecological model to find a tipping point for change and uses multiple strategies (advocacy, social mobilization and behaviour change communication) to achieve the goal of bringing about behavioural change.

Know the context

Evidence from the AIDS and WATSAN sectors demonstrate that interventions are more effective if they address the many levels of influence on behaviour. The socio-ecological model illustrates how individuals with their preferences, knowledge, beliefs and practices, social and cultural norms and empowerment are influenced at the interpersonal level with family, friends and social networks. Likewise, the community and organizational level influences through neighbourhoods or villages, cultural practices, schools, clinics, rules and policies. Social structures, policy, media and systems overarch all other levels of influences (Contento, 2008a). Thus, in an agriculture and nutrition project, it would be short sighted to focus a behaviour-change message or intervention only on married women without taking into consideration

that their husbands and extended families influence their decisions regarding farming and family nutrition. For example, in areas of Mozambique the mother-in-law is particularly influential in what is acceptable behaviour by her daughter-in-law. In this case, a behaviour change intervention must address several different levels of influence because this is the context in which the woman is operating.

Formative research to understand the 'influencers' of conduct is essential to behaviour change if programming is going to be targeted accurately. This may include barrier analysis (to identify the obstacles which individuals face in changing their behaviour), doer-non-doer studies (what are the differences between these groups and how does this inform us?), and examination of positive deviance (who has already changed behaviours and how did they do it?). In this way, it is possible to explore the determinants of behaviour so that the right messaging and activities can be chosen for programme.

Information is never enough

The process of behaviour change starts with providing information but it is only the first step in a much longer process. The mistake of assuming that because people have information, they will change their behaviours has been repeated in all sectors. In reality having information or knowledge rarely translates into changed behaviour. Literature abounds about this disjuncture between knowledge and behaviour change. Hand washing as a critical interruption of disease transmission has been known since 1846 and has been taught widely in the general population and in the health community (CDC, 2000; Grol and Grimshaw, 2003; Twomey, 2006) and yet the *practice* of hand washing must be taught and retaught in countries around the world. Campaigns on smoking, alcohol consumption and nutrition (balanced diets) have educated the public but until they were reinforced at other levels, the information *alone* did not bring the desired behavioural results. Both the AIDS and the WATSAN sectors have suffered from this problem. Many programmes have focused on telling people how to prevent HIV infection, or the importance of defecating in a toilet or pit latrine, but have not taken the target population beyond the information stage. As a consequence, they have not realized the obstacles that prevent people from putting into practice the information they have received, and developing the skills to enact positive behavioural change.

Gender matters

While it is commonly acknowledged that men and women operate differently and are differently affected by interventions and projects, this knowledge is not taken forward into programming so that adjustments are made to address gender difference. For example, the lack of sanitation facilities at schools affects boys and girls differently, particularly as they mature. It is now widely documented that girls will stay home from school when they are menstruating if pit latrines/toilets and water for hand washing are not provided at school. Likewise in an integrated agriculture–nutrition project, access to resources (land, seed, labour) is different for men than for women. Sweetpotato tends to be a crop of home consumption which is the responsibility of the woman until such time as it is commercialized and it becomes the concern of men. As such, conducting a gender analysis should be prioritized in an integrated project. This will affect programming, interventions, training materials and methods, as well as data.

Tap into aspirations (hook onto the familiar and modify existing behaviours)

Understanding the perceived positive or negative consequences of a person performing a behaviour can provide direction in messaging. There are advantages and disadvantages to changing behaviours and unless we try to gain insight and understand it will be difficult to convince people to make changes. Fear as a motivator to change can work but only for a limited time. Early AIDS campaigns used skull and crossbones to

scare people that they would die from the disease. In fact for many who were struggling to feed themselves on a daily basis, the threat of death in the future was less frightening than the imminent hunger of today. Learning from the advertising sector, however, aspirational goals are powerful. Life, health, strength and money appeal to people and advertisers use these aspirational goals liberally in their campaigns. Reducing money spent on medicine and clinics by reducing disease levels is appealing. Showing off healthy smart children appeals to the hearts of most parents. Society approves of these positive aspirations; they fit the societal norms. Programmes in AIDS, WATSAN and health that have tapped into aspirations and hooked onto familiar (rather than unfamiliar) constructs have been more successful than those that did not (Duhigg, 2012).

What can we learn about behavioural change from other food-based approaches to improving diet diversity and nutritional status?

Arimond *et al*. (2011) identified five non-mutually exclusive main pathways through which agricultural interventions may impact on nutrition. These are: (i) increased food availability and access (production for own consumption, filling seasonal gaps); (ii) increased income (through production for sale in markets and hence potential to increase food purchases or higher quality food purchases); (iii) reduction in real food market prices (with increased agricultural production); (iv) shifts in consumer preference (e.g. when programmes include behaviour-change communication); and (v) shifts in control of resources within households and communities (in particular interventions that shift resources, e.g. income, time, etc. towards women). Various factors, for example market access and integration, potential for surplus production within a given setting, pre-existing nutritional knowledge, and consumer preferences and demand will determine which pathway dominates in impacting on nutrition.

Regardless of which of the above pathways is dominant, successful food-based strategies all include nutrition education and behaviour change communication to ensure that the increased access to food translates into improved nutrition and empower women to make educated consumption and nutritionally informed food purchasing choices (HKI, 2010). Demonstration sessions, growth monitoring and community theatre are preferred, rather than lecture sessions (Low *et al*., 2007a). Cooking demonstrations are used to illustrate the best cooking methods to retain nutrients and enhance absorption of micronutrients from garden produce (Faber *et al*., 2006; HKI, 2010). Incorporating gender considerations and livelihoods frameworks into the design of food-based strategies strengthens the impact on nutrition (Arimond *et al*., 2011).

In South Africa, where sweetpotato is eaten as a vegetable, OFSP is introduced in food-based projects together with a variety of other vitamin A-rich vegetables and fruit. In addition, consumption of wild-growing African leafy vegetables is encouraged (Faber *et al*., 2006). Promoting a variety of β-carotene vegetables and fruit helps to overcome seasonal variability and adds variety to the diet. In the Asia-Pacific region, a more holistic approach is used by focusing on all foods rich in micronutrients (not only vitamin A). Year-round availability of micronutrient-rich foods is achieved by planting a large variety of vegetables and fruit. In addition, small animal husbandry (e.g. chickens) is included because of the higher bioavailability of micronutrients in animal foods. This was shown to be successful in improving dietary intake and decreasing micronutrient deficiencies (HKI, 2010).

Partnerships across disciplines are required, particularly a close collaboration between agriculture and nutrition. Berti *et al*. (2004) argues that agricultural projects that had impact on nutrition also invested in four or five types of 'capital' (physical, natural, financial, human and social) as defined in the Sustainable Livelihoods Framework. When selecting crops to plant, agronomic traits, potential to address nutrient deficiencies in the local diets, and motivations

and constraints that determine the household consumption decisions must be considered (Arimond *et al.*, 2011). One of the major challenges to a multi-crop food-based intervention is managing the increased range of seed systems and ensuring sufficient technical expertise for all of the crops and livestock in use.

What can we learn from rural and urban consumers so we can best meet their needs?

People's food choices are influenced by a complex set of interacting factors, namely: (i) biological-determined behavioural predispositions; (ii) experience with food (associative conditioning) leading to people's food preferences; (iii) personal factors, such as perceptions, attitudes and beliefs; and (iv) environmental factors, including food, social, economic and informational environments (Contento, 2008b). An understanding of factors affecting food choices of the target population is therefore needed to develop appropriate behaviour change strategies.

Foods may be viewed differently by urban and rural consumers. In Cameroon, for example, rural adolescents, who had a shortage of food at home, reported that they ate to 'live' and be healthy. Urban poor adolescents had better food availability, although affordability was problematic, and for them food was for health and beauty. Urban rich adolescents had more than enough food, and for them the purpose of the food was for pleasure and beauty (Dapi *et al.*, 2007).

In many African countries, agriculture is the major component of the rural economy and household livelihoods. In rural areas, eating traditional food at home is still common and diet diversity in many settings limited. In urban areas, households rely mostly on purchased food, including processed foods. Poorer households often face high prices of wood and charcoal, leading to reduced frequency of home meal preparation. Urban women who are employed outside the home have less time available to shop for ingredients and prepare meals for the family. In such circumstances, consumption of fast foods outside the house easily increases, and street-food purchases are particularly high in urban areas of Africa (Fanzo, 2012). In Nairobi, one study found 50% of consumers from both a low and a middle-income area of the city consuming street foods 3 days of the week or more (Ogubi, 2007). Fried sweetpotato slices are popular informal foods in some East and West African cities and towns.

Environmental factors affecting food choices are rapidly changing. This is reflected in the global nutrition transition with diets converging from the more traditional diet to a more Westernized diet, characterized by energy dense, often highly refined, foods high in fat, added sugar and salt, and low in micronutrients. In some settings, Westernized diets are considered 'modern' and convenient; foods such as sweetpotato are considered foods of the poor and time-consuming to prepare. The nutrition transition has been documented for low- and middle-income countries in all urban areas and increasingly in rural areas. In African countries, a double burden of malnutrition is emerging (i.e. hunger alongside the health problems associated with over nutrition, such as obesity, diabetes and stroke). Obesity is higher in urban areas in most African countries; but rural obesity is catching up (Popkin *et al.*, 2012). African women, often from poor, food-insecure households are particularly vulnerable to obesity when they experience the nutrition transition (Vorster *et al.*, 2011). Modern food systems, characterized by processing and packaging of food products, and corporate concentration in retailing and distribution (e.g. brand names, large supermarkets) play an important role in the nutrition transition (Ericksen, 2008).

Within the context of the double burden of malnutrition, food-based strategies focusing on diversification of diets should aim for optimal, but prudent diets for all, and under- and over-nutrition should be addressed simultaneously in the communication strategies (Vorster *et al.*, 2011).

What can we learn from private-sector marketing firms about consumers' behaviour and their food choices?

In developed economies, private agro-processing firms spend considerable resources in understanding what consumers want. There is widespread recognition that consumers differ in their preferences. There are consumers who 'eat-to-live' and follow predictable purchasing patterns; others love innovative products and are adventurous in approaching new foods. A market-oriented company seeks to understand and exploit distinct consumer segments in a timely fashion, paying attention to socio-economic, age group, ethnic and gender differences. Any company in the world seeks to build brand loyalty. This is often done through advertising that implies a connection between a product and a desirable goal, evoking certain emotions (Lister, 2013).

Consumer food choice, the way in which consumer's choose to spend their money on food, is driven in all societies by the consumer's income, the food products' prices and quality. The concept of quality, however, has undergone considerable change in the past 20 years, particularly in regards to urban consumers. Grunert (2003) describes four groups of quality attributes:

1. *Sensory attributes* are the classical food quality aspects of taste, appearance and smell, with taste as the dominant aspect.
2. *Health/nutritional attributes* have been increasing in importance, as evidence by the emergence of *functional foods*, food products which have an added positive health benefit.
3. *Process attributes* refer to consumers' interest in the way a food product has been produced. In Europe and the USA, some consumers pay premiums for organic products.
4. *Convenience attributes* are aspects of the product which save time or energy for the household, whether during shopping, storage, preparation, eating and/or disposal.

Cultural differences between and within countries determine the relative weight of the four categories of quality attributes on food choice. Differences in taste preferences are widely recognized. In the case of sweetpotato, adult consumers in the Americas prefer low dry matter varieties (18–23%); whereas adults in SSA prefer moderate to high dry matter types (28% and above). However, the perception of what is healthy, what is convenient, and which types of production are acceptable also can differ significantly (Grunert, 2003).

Nutrition education efforts in SSA focus on developing and transmitting key messages and it is often assumed that if the target group understands those messages, the desired change in behaviour will occur. However, organizational behaviour and marketing specialists have investigated how the way in which an innovative idea is communicated determines whether it will survive or not in the competitive market place, in other words, what makes the idea *stick* (Heath and Health, 2008).

Their six principles should be considered when designing a campaign for a new product such as OFSP roots or OFSP-based processed products, namely:

1. Simplicity. Focus on ideas/messages that are simple, yet profound.
2. Unexpectedness. Generate interest and curiosity by violating people's expectations.
3. Concreteness. Explain ideas in terms of human actions and non-ambiguous language.
4. Credibility. The idea must be credible; preferably suggest how to test this idea oneself.
5. Emotions. Make the client feel something.
6. Stories. Tell stories to get people to act on the idea/message.

The factors influencing urban consumer food choice fall into five broad categories: personal, social, economic, environmental and psychological (Dolceta (European Union online consumer education), 2013). Most lower socio-economic status urban consumers purchase their OFSP as fresh roots or fried slices in informal markets. A few have access to OFSP processed products such as doughnuts. Higher socio-economic status consumers also can use informal markets, but many in major urban centres have shifted to more formal markets, including shops and supermarkets. Higher end consumers are

more likely to prioritize their selection based on taste (personal), current trends (social) and style of packaging (psychological) than poorer consumers.

To reach lower socio-economic status consumers, the dominant factors will be price relative to other sources of energy, followed by taste and health-driven preferences and convenience. The price will be determined to a large extent by transport costs from production zones to the urban centre. Consideration should be given to training wholesale and retail traders about the value of OFSP, facilitating linkages between traders and producers, and providing promotional signs, aprons and umbrellas to those agreeing to separate out OFSP from other types of sweetpotato.

55.6 Discussion

By reflecting on the OFSP experience to date and reviewing progress of the health and marketing sectors concerning behavioural change, it is clear that the knowledge of what works at the community level to improve vitamin A intakes among women and young children is much greater than knowledge about the how to cost-effectively reach rural and urban consumers purchasing OFSP roots and processed products. It is clear that nutrition interventions at the community level should discuss the benefits of OFSP and provide key messaging concerning breastfeeding, complementary feeding of young children, combining foods to create a balanced diet and vitamin A rich foods. That is the minimum.

Key recommendations for how to approach rural households can be summarized in a checklist:

1. Define which behaviours must be addressed or developed in order to integrate OFSP into the farming system and rural household. Conduct formative research to understand barriers to behaviour change and how best to tackle them. Consider bringing in a specialist to train designated staff on how to do this kind of qualitative work, so that periodically teams can engage in operations research and make adjustments during the project life span.
2. Target households (i.e. both men and women). Although women are the gatekeepers to household nutrition, they do not act in isolation. Access to family resources (land, seed, labour) are frequently controlled by men. Family (mothers, mothers-in-law) and friends influence the women – either by positive or negative reinforcement of behaviours based on social norms and the information they have. In this respect it is more beneficial to address the household unit even if it means providing certain messages to women and other messages to the influential groups such as men and grandmothers (mothers-in-law).
3. Segment the population and design messages and interventions that are targeted to their specific behaviours, aspirations and obstacles. While the overarching key message may be for everyone, the information, skills and obstacles being faced are not the same. Mothers need to learn how to incorporate OFSP into the family diets while men may be more concerned with marketing OFSP. Use methods such as TIPs to help understand the challenges caregivers face in making the proposed change(s).
4. Understand the cultural beliefs and practices around certain foods and design messages appropriately.
5. Behaviour change messages should be clear, comprehensive and actionable to the group for which they are intended. Keep it simple with one action per message or people will become confused.
6. Repeat behaviour change messages frequently, and reinforce the messages with practice so that change is long lasting.
7. Identify and promote the use of lowest-cost fat source in OFSP-containing porridges and other recipes, given the importance of a small amount of fat in increasing bioefficacy of β-carotene in OFSP.
8. Raise awareness and create a supportive environment for change through cost-effective community radio programmes, jingles and talk shows in local languages.
9. Focus on the skills that rural consumers need to develop in order to sustain the behaviour change which has been identified.

Organize practical cooking demonstrations using locally available foods and involving the mothers so that they gain the skills to enable them to feed their children dishes enriched with OFSP.

10. Use pre-existing social networks to encourage the sharing of information to friends, neighbours and peers. This creates positive peer pressure and encourages a change at the community level which supports everyone. It is easier to make a change if others around you are doing the same. If resources permit, get a key public figure to endorse the effort in the local media.

11. Involve structures within the community (e.g. schools, health centre and clinics, radios, extension/community workers) to reinforce messages from all directions. Align messages to be consistent with existing messages being promoted by government to build a synergy that can take things forward.

12. Build in an operations research component as part of the intervention strategy to periodically reassess which techniques are succeeding in getting adoption of OFSP and its appropriate use.

On the marketing side, it is clear that there is much to be learned from the private sector and the health community. All seem to agree that *aspirational* messaging, using images of healthy children and productive families, is better than showing the negative consequences of VAD.

Reaching higher socio-economic status consumers will require a more substantial financial investment, preferably done in collaboration with a private-sector agro-processor with existing marketing channels, funds to support promotion campaigns and a commitment to support local farmers in the development of reliable supply chains. Extensive advertising and other promotional efforts will be needed as the dominant image of sweetpotato as a food for the poor must be shifted, with OFSP being promoted as a health food for all. Investing in communication specialists will help to design promotion messages that will 'stick' in the selected environment. In Rwanda, the launch of the Golden Power biscuit has begun to change the opinion of policy makers about sweetpotato's potential commercial value. Facebook, Twitter and the radio are used to make consuming Golden Power biscuits 'cool' among young adults. In areas with internet services, investments in social media can be an effective way to create demand and interest, particularly among younger consumers. If funds for reaching urban consumers are limited, emphasis should be placed on reaching consumers in informal markets, as the risk of VAD is higher in this group.

Evidence is strong that consuming OFSP can significantly contribute to lowering the prevalence of VAD. Research is still needed, however, to devise more 'field friendly' and precise biological indicators than serum retinol.

Considerable progress has been made in understanding the bioaccessibility of β-carotene in OFSP roots and processed OFSP-based products. Although heat processing reduces β-carotene retention, the loss in retention is compensated for by improved bioaccessibility. Fat in the meal increases the bioaccessibility of β-carotene in OFSP, but only small amounts (3–5 g) are needed. Emphasis should be placed on using medium intensity or dark orange OFSP varieties whenever possible, particularly for baked products. Since sweetpotato purée is more economically viable than sweetpotato flour, research is needed to identify cost-effective ways to store purée without significant loss of quality. Also, greater investment in postharvest storage is needed.

55.7 Way Forward

To build the evidence base, most interventions used OFSP as the key intervention. Building on that solid base, going-to-scale at reasonable cost with OFSP also will need to focus on how to successfully integrate it into existing initiatives and frameworks seeking to improve nutrition and/or agricultural productivity and/or market opportunities. The options will be broad, recalling the multiple roles that sweetpotato can play in the food system: (i) as a staple food; (ii) as

a vegetable (both the roots and the leaves); (iii) as a breakfast or snack food; (iv) as a resilient, food security crop in maize-based systems subject to the impact of climate change; (v) as an animal feed (dual purpose for food and feed); and (vi) as an ingredient in processed products.

In the past 5 years, there has been increasing interest among policy makers in SSA about integrating nutritional concerns into agricultural interventions. African leaders committed themselves in 2003 to developing detailed agriculture plans at the country level that align with the principles of the Comprehensive African Agriculture Development Programme (CAADP) and ensuring that 10% of the GDP is used for agriculture. In 2012 and 2013, efforts were being made to help mainstream nutrition into existing and developing agriculture investment plans through a series of sub-regional workshops. CAADP documentation explicitly recognizes investment in nutrient-dense crops such as OFSP as quality investment (NEPAD and CAADP, 2008). The CAADP framework also heavily supports the use of home-grown school feeding programmes as well as vegetable gardens to address chronic undernutrition. OFSP could be built into both of these programmes.

The Scaling Up Nutrition (SUN) movement is perhaps the best opportunity for OFSP integration. It emphasizes combatting chronic undernutrition in children under 2 years of age through establishing multi-dimensional community-based nutrition programmes. As of March 2013, 22 African countries had joined the SUN movement, with 21 of them already having developed nutrition investment plans. Integrating OFSP into SUN-financed community nutrition programmes will provide an opportunity to significantly lower the cost of the OFSP intervention because they are focused on the key target groups at risk of VAD and they recognize the need for staff working at the community level. Drawing on behavioural change and social marketing techniques outlined above will enable researchers and practitioners to improve the techniques and tools needed to get adoption and proper utilization of OFSP.

There is no doubt that OFSP can also play a significant role in a range of food and nutrition security, value chain and climate change mitigation interventions. Additional research is needed on integrated crop management, postharvest management, marketing systems and product development for its full potential to be realized in these areas. Attention should also be paid to how to best promote sweetpotato leaves, to maximize their potential nutrition contribution. To monitor uptake, it is critical for national surveys and other data collection efforts to distinguish between OFSP and non-OFSP sweetpotato types in their survey instruments. With a combined multi-disciplinary effort, prospects are excellent for OFSP to significantly contribute towards reducing food insecurity and VAD in the coming decade.

Notes

[1] United Nations Children's Fund (UNICEF), the World Health Organization (WHO), the Canadian International Development Agency (CIDA), the UK's Department for International Development (DFID), the United States Agency for International Development (USAID), and the Micronutrient Initiative (MI).

[2] Biofortification is the process of breeding staple food crops with high contents of key micronutrients. Currently the emphasis is on breeding crops with higher provitamin A (β-carotene), iron and zinc.

[3] The disability-adjusted life year is a measure of overall disease burden, reflecting the number of years lost due to ill health, disability or early death.

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