ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 2
April 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

CHAPTER 15

INTRODUCING ORANGE SWEET POTATO: TRACING THE EVOLUTION OF EVIDENCE ON ITS EFFECTIVENESS

de Brauw A[1*], Gilligan DO[2] and J Low[3]

*Corresponding author email: A.Debrauw@cgiar.org

[1]Markets, Trade, and Institutions Division, International Food Policy Research Institute, Washington, DC

[2]Poverty, Health and Nutrition Division, International Food Policy Research Institute, Washington, DC

[3]International Potato Center, Nairobi, Kenya

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 2
April 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

The introduction of orange sweet potato (OSP), rich in vitamin A, can have important and lasting impacts on reducing vitamin A deficiency among smallholder farmers in the developing world. In this paper, we describe the evolution of evidence about the effectiveness of disseminating OSP to smallholder farmers on vitamin A deficiency. We trace projects from a small trial in 10 villages in western Kenya through the Reaching End Users program in Mozambique and Uganda that reached thousands of households in both countries, while demonstrating that households receiving integrated programs teaching them to grow OSP and the nutritional benefits of vitamin A had notable impacts on the probability of vitamin A deficiency and on biological markers for vitamin A in women of child-bearing age and young children, relative to members of households not selected for participation. The evidence generated through research has played an important role in efforts to disseminate the crop more widely, and future evaluations will help build understanding about how OSP can be combined with other interventions, such as health visits or disseminating additional biofortified foods.

Key words: Orange Sweet Potato, Vitamin A, Impact Evaluation, Biofortification

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 2
April 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

INTRODUCTION

A recently published authoritative systematic review of smallholder interventions declared that orange sweet potato, which is rich in vitamin A and can therefore help address vitamin A deficiency, a form of malnutrition, "presented the most promising approach" to improving food security among smallholders [1]. Given the broad array of agricultural interventions attempting to alleviate productivity constraints on smallholders and improve their food security [2], this statement is quite impressive. In this paper, we trace how impact evaluations related to orange sweet potato (OSP) evolved, describe the evidence they have generated, and indicate what lessons and innovations can be expected from OSP interventions in the future.

An early project first established that OSP could be disseminated using a farm-based approach to improve children's diets [3]. The project provided OSP and nutrition education to 10 women's groups in western Kenya, and found the frequency of consumption of vitamin A-rich foods by children under five years of age nearly doubled. This project can be thought of as a predecessor to the larger *Towards Sustainable Nutrition Improvement* (TSNI) project, implemented between 2002 and 2004 in Zambézia, Mozambique [4, 5]. TSNI included about 500 project participant households in Namacurra and Mopeia districts of Zambézia province, and used approximately 250 households in Nicoadala district as a control group that did not receive OSP. TSNI first used an integrated delivery approach, simultaneously including an agricultural component to provide access to OSP vines and teach farmers how to grow and maintain them; a nutrition component that increased nutrition knowledge and stimulated OSP demand; and a market component meant to stimulate exchange and increase the crop's sustainability. During the same period, laboratory and feeding trials under controlled settings established that OSP has good-to-excellent amounts of a highly bioavailable form of vitamin A, leading to substantial improvements in vitamin A status in children consuming typical quantities of OSP [6, 7].

The *Reaching End Users* (REU) project, which followed TSNI, was implemented in both Mozambique and Uganda between 2006 and 2009, and was designed as a modified version of TSNI meant to test the cost-effectiveness of two models of scaling up an integrated OSP intervention [8]. The two intervention models differed primarily in timing and intensity of activities and therefore in delivery costs. In the first year, the two models were identical in agricultural extension and nutrition education activities. Rather than testing the efficacy of dropping certain components of the intervention, differences between the two models occurred in the second year. In Model 1, the high intensity of extension visits and nutrition messages was maintained in year two. In Model 2, the activities in agriculture and nutrition were scaled back substantially in the second year to provide cost savings. The REU was implemented in both countries as a randomized control trial, so changes among households in the two model groups and with the control group can be considered as causal.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 2 April 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

DATA COLLECTION

For use in evaluating the impacts of both projects, the TSNI and REU included data collection on both agricultural and nutrition outcomes, making them somewhat unique. From a nutrition perspective, the most intense part of the data collection was a dietary intake survey, which used a quantitative 24-hour recall methodology. In the REU, the method was adapted from an interactive, multiple-pass method developed previously for use in Malawi [9]. Standard recipe data were collected from women in project communities in advance, to minimize the respondent burden in recalling recipes during the survey. In each study, the quantitative dietary and nutrition surveys primarily followed a set of reference children (Table 15.1).

In both cases, dietary intake data were used to estimate each individual's consumption of food energy, protein, vitamin A, and other micronutrients in a 24-hour period using the following procedure. A table of conversion factors was compiled from local sources, where possible, to convert all food consumed into the weight of each food consumed. Weights were then converted into energy and nutrient intakes using a food composition table compiled for this project, specific to each country.

In both TSNI and in the Uganda component of the REU, serum retinol, a measure of vitamin A in blood samples, was also collected from reference children. The distribution of serum retinol in a population provides information about the vitamin A status of that population; in particular, it indicates vitamin A deficiency in a population when a specific proportion of that population has serum retinol values below a specific cutoff. In both studies, blood samples providing measures of serum retinol and markers for infection were collected at the beginning and near the end of each component.

RESULTS

Both TSNI and the REU had large, statistically significant impacts on adoption and retention of OSP, vitamin A intakes among reference children, and serum retinol (Table 15.1). We combined results from the two REU models, as statistical tests suggest that they do not differ in either country, suggesting the cheaper model was more cost effective. Both projects led to high levels of adoption of OSP, which is defined as continuing to grow OSP in the year after the project in Mozambique and growing OSP four seasons after receiving vines in Uganda. The difference in vitamin A intakes between treatment and control groups was large in all three cases, at 250 µg retinol activity equivalents (RAE) for the reference children in the REU in Mozambique, 390 µg RAE for reference children in the REU in Uganda, and 894 µg RAE among children in TSNI, the latter of which was a more intense intervention.[1] All differences are statistically significant at the 5 percent level or better. Finally, where blood was collected, significant impacts on serum retinol were observed. In the TSNI, at endline serum retinol

[1] A retinol activity equivalent (RAE) is a measure of the amount of vitamin A that can be actively absorbed by the body. For reference, the US recommended daily allowance of vitamin A is 300 µg among children aged under 4 years, 400 µg among children aged 4-8 years, and 700 µg among women over 14 years old.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 2
April 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

levels among reference children were 0.076 µmol/L higher in the treatment than in the control. In the Uganda REU, when children had a baseline serum retinol concentration below 1.05 µmol/L, their serum retinol increased by 0.075 µmol/L when exposed to the REU. Whereas this increase is small relative to impacts of a megadose of vitamin A given to mothers upon birth of newborns [10], the impact remains meaningful as it demonstrates the potential for OSP to improve the nutritional status of children with low serum retinol.

The REU had short term impacts on nutrition and health measures beyond those on reference children: evidence in both countries demonstrates large impacts on vitamin A intakes by mothers [11, 12]. Among the repeated cross-section of children aged 12-35 months at the time of each survey, the prevalence of inadequate vitamin A intakes declined by 20-35 percentage points in Mozambique and 26-36 percentage points in Uganda in the treatment group relative to the control. In Mozambique, diarrhea prevalence was reduced among children under 5 in treated farmer groups relative to the control group; the reduction in diarrhea prevalence is attributable to OSP consumption [13]. We can conclude that the REU had positive impacts on both nutrition and child health.

The REU was designed to test models of cost-effectiveness of OSP dissemination, and as the less intensive model always had similar impacts as the more intensive and costly model, cost estimates per beneficiary can be based on scaling up a modified version of the less intensive model [14]. As impacts of the REU were largely mediated through vine distribution rather than through learning messages [14], cost estimates can be based on a streamlined version of demand creation. As a consideration for further scaling up the project further, costs per individual beneficiary were between US$26 and US$52 in present value when counting all targeted households and indirect beneficiaries, and could be reduced by between 33 and 40 percent. Moreover, better strategies to encourage diffusion could further reduce costs per beneficiary [15]. However, these calculations miss longer term benefits. As some households in Uganda continue to grow OSP after the project ended [16], OSP continues to diffuse both over space to areas outside the original project area, and over time to beneficiaries that were not yet born as of the 2009 endline survey. Accounting for these beneficiaries would further reduce costs per beneficiary. The sustained impacts of biofortification after a project ends is a key argument in favor of biofortification versus other micronutrient interventions, since they only affect malnutrition as long as they are continuously funded.

FUTURE INNOVATIONS

Further projects are currently in the process of developing additional knowledge about how to cost effectively disseminate OSP vines, how to combine OSP with other health interventions, and how to develop improved products from OSP. In Uganda, an impact evaluation associated with the *Developing and Delivering Biofortified Crops* project is building on findings about diffusion from the REU [17], by randomizing the percentage of individuals within communities receiving vines to attempt to optimize the number of indirect beneficiaries. A recently completed project in western Kenya, *Mama SASHA*, integrated OSP promotion and production with public health care services by giving

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 2
April 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

vouchers for vines to pregnant mothers visiting ante-natal clinics; preliminary results suggest positive impacts on children consuming vitamin A rich foods and increased use of ante-natal services [18]. The *Super Foods* project in Rwanda, working through public-private partnerships to develop a value chain for OSP, has found that developing OSP purée (steamed and mashed roots) for processed bakery products leads to higher quality but cheaper products than those made with OSP flour [19] or, in Mozambique, is superior in vitamin A content to dried chips [20].

CONCLUSION

The introduction of OSP to smallholders has been accompanied throughout its evolution by innovative impact evaluations that have examined agricultural, socioeconomic, nutrition, and health outcomes. The impact evaluations have helped provide strong evidence about the effectiveness of disseminating OSP through an integrated approach, and have provided evidence about the cost effectiveness of these interventions. This evidence has played an important role in efforts to disseminate the crop more widely, and future evaluations will help build understanding about how OSP can be combined with other interventions, such as health visits or disseminating additional biofortified foods.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 2 April 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 15.1: Selected Results on Household OSP Adoption, Dietary Intakes and Serum Retinol among Reference Children, and Serum Retinol, TSNI and REU Interventions

	TSNI, Mozambique	REU, Mozambique	REU, Uganda
Age Range at baseline, Reference Children	4-38 months	6-35 months	3-5 years
Percent of Households Adopting OSP	79%	68%	61%
Difference in Vitamin A Intakes,	894	249.3	389.8
Reference Children, Endline (g RAE)	(203)	(83.6)	(115.9)
Difference in Serum Retinol, Endline	0.076	-	0.075
(mmol/L)	(0.023)		(0.017)

Notes: Reference Children were chosen at baseline and followed through each study. The percent of households adopting OSP is the difference between treatment and control households; standard errors in parentheses are adjusted for clustering of sample for vitamin A intakes and for serum retinol in Uganda; figure for serum retinol in TSNI uses child level fixed effects and a heteroscedasticity robust standard error. Serum retinol result in Uganda is among children who were below 1.05 μmol/L at baseline. The intervention lasted 2 years in TSNI and the REU in Uganda, and 3 growing seasons in the REU in Mozambique.

Sources: [8], [11], and [21], and authors' calculations.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 2 April 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

REFERENCES

1. **Stewart R, Langer L, da Silva N, Muchiri E, Zaranyika H, Erasmus Y, Randall N, Rafferty S, Korth M, Madinga N and T de Wet** The Effect of Training, Innovation, and New Technology on African Smallholder Farmers' Economic Outcomes and Food Security: A Systematic Review, Campbell Systematic Reviews 2015:16.

2. **Jack K** Market Inefficiencies and the Adoption of New Agricultural Technologies in Developing Countries, 2013 Literature Review, Agricultural Technology Adoption Initiative, J-PAL (MIT) and CEGA (UC Berkeley).

3. **Hagenimana V, Low J, Anyango M, Kurz K, Gichuki ST and J Kabira** Enhancing vitamin A intake in young children in western Kenya: Orange-fleshed sweet potatoes and women farmers can serve as key entry points. *Food and Nutrition Bulletin* 2001, **22(4):** 376-87.

4. **Low JW, Arimond M, Osman N, Osei AK, Zano F, Cunguara B, Selemane MDL, Abdullah D and D Tschirley** Towards Sustainable Nutrition Improvement in Rural Mozambique: Addressing Macro- And Micro-Nutrient Malnutrition Through New Cultivars And New Behaviors: Key Findings. Donor Report, Michigan State University, 2005.

5. **Low JW, Arimond M, Osman N, Cunguara B, Zano F and D Tschirley** Ensuring supply and creating demand for a biofortified crop with a visible trait: Lessons learned from the introduction of orange-fleshed sweet potato in drought-prone areas of Mozambique. *Food and Nutrition Bulletin* 2007, **28:** S258-S270.

6. **Van Jaarsveld P, Faber M, Tanumihardjo SA, Pestel P, Lombard CJ and AJ Benade** Beta-carotene-rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. *American Journal of Clinical Nutrition* 2005, **81:** 1080-1087.

7. **Haskell MJ, Jamil KM, Hassan F, Peerson JM, Hossain MI, Fuchs GJ and KH Brown** Daily consumption of Indian spinach (Basella alba) or sweet potatoes has a positive effect on total body vitamin A stores in Bangadeshi men. *American Journal of Clinical Nutrition* 2004, **80:** 705-714.

8. **HarvestPlus** Reaching and Engaging End Users (REU) with Orange-Fleshed Sweet Potato in Eastern and Southern Africa: Final Report. 2010.

9. **Gibson RS and EL Ferguson** An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries. HarvestPlus Technical Monograph 8, 2008. Washington DC and Cali: International Food Policy Research Institute and International Center for Tropical Agriculture.

10. **Roy SK, Islam A, Molla A, Akramuzzaman SM, Jahan F, and G Fuchs** Impact of a Single Megadose of Vitamin A at Delivery on Breastmilk of Mothers and Morbidity of Their Infants. *European Journal of Clinical Nutrition* 1997, **51**: 302-307.

11. **Hotz C, Loechl C, de Brauw A, Eozenou P, Gilligan DO, Moursi M, Munhaua B, van Jaarsveld P, Carriquiry A and JV Meenakshi** A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women. *British Journal of Nutrition* 2012, **108**: 163-176.

12. **Hotz C, Loechl C, Lubowa A, Tumwine J, Ndeezi G, Masawi AN, Baingana R, Carriquiry A, de Brauw A, Meenakshi JV and DO Gilligan** A Large Scale Intervention to Introduce Beta Carotene Rich Orange Sweet Potato Was Effective in Increasing Vitamin A Intakes among Children and Women in Rural Uganda. *Journal of Nutrition* 2012, **142**: 1871-1880.

13. **Jones K and A de Brauw** Using agriculture to improve child health: Results from a randomized controlled trial on Vitamin A intake. *World Development* 2015, **74**: 15-24.

14. **de Brauw A, Eozenou P, Gilligan DO, Hotz C, Kumar N and JV Meenakshi** Biofortification, Crop Adoption, and Health Information: Impact Pathways in Mozambique and Uganda. HarvestPlus Discussion Paper 21, 2015.

15. **McNiven S and DO Gilligan** Networks and Constraints on the Diffusion of a Biofortified Agricultural Technology: Evidence from a Partial Population Experiment. Working paper, 2012.

16. **McNiven S, Gilligan DO and C Hotz** Sustainability of Impact: Dimensions of Decline and Persistence in Adoption of a Biofortified Crop in Uganda. Working paper, 2015.

17. **Ashour M, Gilligan DO, McNiven S and L Billings** Impact Evaluation of the HarvestPlus Project Developing and Delivering Biofortified Crops in Uganda: Baseline Report. Washington, DC: International Food Policy Research Institute, 2014.

18. **International Potato Center** Integrating Health and Agriculture to Maximize the Nutritional Impact of Orange-Fleshed Sweet potato: Results from the Mama SASHA project endline survey in Western Kenya. Sweet potato Action for Security and Health in Africa (SASHA) project brief, September 2015.

19. **International Potato Center** Rwanda Sweet potato Super Foods: Market Chains that Work for Women and the Poor. SASHA project brief, August 2015.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 2 April 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

20. **Low JW and P van Jaarsveld** The potential contribution of bread buns fortified with beta-carotene-rich sweet potato in central Mozambique. *Food and Nutrition Bulletin 2008,* **29:** 98-107.

21. **Low JW, Arimond M, Osman N, Cunguara B, Zano F and D Tschirley** A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations among young children in rural Mozambique. *Journal of Nutrition* 2007, **137(5):** 1320-1327.