Potential of orange-fleshed sweetpotato in raising vitamin A intake in Africa

Vital Hagenimana
International Potato Center (CIP), Sub-Saharan Africa Region, P.O. Box 25171, Nairobi, Kenya

Introduction

Deficiencies in vitamin A, iron, and iodine are widespread in Africa, making millions of people more vulnerable to illness, fatigue, blindness, and memory loss and increasing the possibility of mental retardation among their children. Enhancing these micronutrients result in improved well being and physical development. Infants and pre-school children could have greater chances of survival, better health, and increased intellectual capacity. Women could have improved pregnancy outcomes and increased productivity.
It is common knowledge that an adequate dietary level of vitamin A is essential for normal vision and dietary vitamin A deficiency causes debilitating health problems such as xerophthalmia, corneal lesions, keratomalace, and, in many instances death. The World Health Organization (1995) reports many of these problems affecting young children in Africa.

Supplementation with Vitamin A in capsule form can cure people with vitamin A deficiency, but the complementary promotion of food-based agricultural interventions are particularly effective in reducing sub-clinical vitamin A among low-income consumers. This requires a collaborative model where nutritional and community development expertise is linked to the production-focused interventions to increase vitamin A intake. A recent UNICEF/WHO joint policy document concluded that a mixture of approaches should be supported, including supplementation, dietary diversification and fortification (IVACG, 1995). An appropriate intervention strategy must be technically feasible, cost-effective, and sustainable. Vitamin A is the micronutrient most amenable to agriculturally-based interventions, which are particularly appropriate in the African context.

Carotenoids represent the most widespread group of naturally occurring pigments in nature. They are primarily of plant origin and β–carotene, with few exceptions, predominates. β–Carotene serves as an important nutritional component in foods, as a major precursor of vitamin A, and provides pleasant yellow-orange colors to foods (Simon, 1997). There is also much epidemiological evidence that carotenoids may help in the prevention of certain degenerative diseases (Elliott, 1999).

There are only two crops that can supply significant quantities of both calories and pro-vitamin A: sweetpotato and palm oil. Palm oil is not produced in significant quantities in eastern or southern Africa where vitamin A deficiency is an endemic, chronic problem, but sweetpotato is widely grown and increasingly important. Millions of poor small-scale farmers, mostly women, produce the crop primarily for home consumption and to a lesser extent for commercial sales in local or urban markets. The increasing importance of sweetpotato in sub-Saharan Africa is largely attributable to the crop's relatively high productivity across a range of environments, and its short cropping season, and flexible planting and harvesting schedules (Ewell, 1993). Periodic droughts and the rising costs of grain production have also contributed to the increasing importance of sweetpotato both for food security and income generation.

The problem is that most of the varieties currently grown have white or cream flesh and supply little or no beta-carotene (Purcell, 1962; Purcell and Walter, 1968; De Almeida-Muradian et al., 1992; Takahata et al., 1993; Hagenimana et al., 1999). The solution is to introduce new orange-fleshed varieties of sweetpotato that are rich in pro-vitamin A which are high-yielding, well-adapted to local farming systems, and which meet local standards of culinary quality. This must be linked to education on nutritional quality and on new forms of utilization to promote their adoption and use.

Sweetpotato potential:

CIP's sweetpotato research and development program in sub-Saharan Africa is aimed at enhancing the role of the crop for food security, nutrition and income generation for small farmers in the region. Taste tests conducted in East Africa revealed that adults prefer varieties with a high dry matter content (greater than 27%), whereas children prefer weaning foods made with low dry matter content varieties. Orange flesh color is not in itself a barrier to acceptance. In different agro-ecological zones of East Africa, a number of high yielding cultivars which are high in both pro-vitamin A and dry matter have been identified (Gichuki et al., 1997; Carey et al., 1999). The levels and stability of pro-vitamin A have been evaluated (K'osambo et al., 1998; Hagenimana et al., 1999a), and their potential use in locally processed foods has been assessed and validated (Omosa, 1997; Hagenimana and Owori, 1997; Hagenimana et al., 1998, Fawzia et al., 1999). The work is being conducted in close collaboration with partners in national agricultural research and extension systems, universities, and NGOs.

Case study to illustrate sweetpotato potential

An action research project (Low et al., 1997, Hagenimana et al., 1999b) was recently implemented by the Kenya Agricultural Research Institute (KARI), in collaboration with CIP and CARE International. Orange-fleshed varieties of sweetpotatoes, both high yielding and rich in beta-carotene, were introduced to women farmers. The results demonstrated that orange-fleshed sweetpotatoes, both eaten alone and as ingredients in processed foods, were highly acceptable to both producers and consumers in the target communities. Using standard methods of analysis, it was demonstrated that the increased consumption did in fact contribute to the alleviation of vitamin A deficiency in case-study households.

The intervention sites were in rural western Kenya, an area in which farmers have traditionally produced sweetpotato for home consumption and markets. The trial intervention worked with women's groups in two Districts and compared two extension packages to promote adoption and consumption of varieties of orange-fleshed sweetpotatoes rich in beta-carotene. Both packages included agricultural extension support to promote cultivation of the new orange-fleshed sweetpotato varieties to improve vitamin A intake. In addition, one of the packages also included nutrition education, training in processing methods and home-visits to review parts of the lessons as needed and answer questions, which at times involved the reconciliation of nutrition education with cultural beliefs or patterns. Without an opportunity to discuss and understand these issues, the women were much less likely to adopt new varieties of an unfamiliar color, and change the vitamin A consumption patterns in their households.

The main nutrition outcome indicator in this study was the frequency with which children under five years of age consumed vitamin A-rich foods, as measured by an index developed by the NGO Helen Keller International. The increase in HKI scores in intervention communities was sizable, compared to the control groups. Improvements in intake of animal and plant sources of vitamin A contributed to the improvement in HKI scores. That said, increased consumption of orange-fleshed sweetpotato was an important factor in the increased intake of Vitamin A.

But this research was about more than demonstrating nutrition results. It also was about how those results could be achieved. There was a linkage of agricultural innovation (orange-fleshed sweetpotatoes) with simple processing technologies (flour, mandazis, chapatis, buns); micro-scale enterprise development, and increased knowledge of women farmers about the relationships between production, processing, marketing, food preparation, and the health and nutrition of their families.

Conclusion

The intervention trials demonstrated that linking the promotion of food production and processing through agricultural technologies and extension activities to the promotion of food consumption through health and nutrition education worked. Expanding and replicating the approach and methods used in the study for a large sample and in other African countries where vitamin A deficiency is prevalent could lead to significant gains in reducing vitamin A deficiency.

Acknowledgments
Author Hagenimana is partially funded by the Department for International Development (DFID) of the United Kingdom, the Crop Postharvest Research Programme [R7036]. However, the DFID can accept no responsibility for any information provided or views expressed.

References

Carey, E.E., Hagenimana, V., K'osambo, L., Oyunga, M.A., Benesi, I., Smit, N., Ocitti p'Obwoya, C., Turyamureeba, G., Ndolo, P.J., and Low, J. 1999. Using orange-fleshed sweetpotato varieties to combat vitamin A deficiency and enhance market opportunities for smallholder farmers in sub-Saharan Africa, pp.157-168. In: ***Food Security and Crop Diversification in SADC Countries: The Role of Cassava and Sweetpotato,*** M.O. Akoroda and J.M. Teri (eds.). Proceedings of the scientific workshop of the Southern African Root Crops Research Network (SARRNET) held at Pamodzi Hotel, 17-19 August, 1998, Lusaka, Zambia. 476p.

De Almeida-Muradian, L.B., De Penteado, M.V.C., and De Ferreira, V.L.P. 1992. Relationship between carotenoid content and Hunter colour parameters of Brazilian sweetpotato. Rev.Espanol. Ciencia Technol. Alimen. 36: 611-619.

Elliott, J.G. 1999. Application of antioxidant vitamins in foods and beverages. Food Technol. 53 (2): 46-49.

Ewell, P.T. 1993. Sweetpotato in Africa: Research priorities to stimulate increased marketing. Paper presented at the International Workshop on Methods for Agricultural Marketing Research. March 16-20, IARI Campus, new Dehli, India.

Fawzia, A., Karuri, E.G., and Hagenimana, V. 1999. Sweetpotato ketchup: Feasibility, acceptability, and production costs in Kenya. African Crop Sci. J. 7: 81-89.

Gichuki, S.T., Hagenimana, V., Low, J., Oyunga, M.A., Carey, E.E., and Kabira, J.N. 1997. Involving women groups in the evaluation of introduced high β–carotene sweetpotato varieties. Proceedings of the 4th Triennial Congress of the African Potato Association held 23-28 Feb. 1997 in Pretoria, South Africa, p. 228-233.

Hagenimana, V. and Owori, C. 1997. Feasibility, acceptability, and production costs of sweetpotato-based products in Uganda, p. 276-281. CIP Program Report 1995-96, CIP, Lima, Peru.

Hagenimana, V., Carey, E.E., Gichuki, S.T., Oyunga, M.A., Imungi, J.K. 1999a. Carotenoid contents in fresh, dried and processed sweetpotato products. Ecol. Food Nutr. 37: 455-473.

Hagenimana, V., Karuri, E.G., and Oyunga, M.A. 1998. Oil content in fried processed sweetpotato products. J. Food Proces. Preserv. 22: 123-137.

Hagenimana, V., Oyunga, M.A., Low, J., Njoroge, S.M., Gichuki, S., and Kabira, J. 1999b. The effects of women farmers' adoption of orange-fleshed sweetpotatoes: Raising vitamin A intake in Kenya. ICRW/OMNI Research Program, Research Report Series 3. International Center for Research on Women, Washington, DC, 24p.

International Vitamin A Consultative Group (IVACG) (1995). Two decades of progress: Linking knowledge to action: Report of the XVI International Vitamin A Consultative Group meeting, Chiang Rai, Thailand, 24-28 October, 1994.

K'osambo, L.M., Carey, E.E., Misra, A.K., Wilkes, J., and Hagenimana, V. 1998. Influence of age, farming site, and boiling on pro-vitamin A content in sweetpotato (Ipomoea batatas (L.) Lam.) storage roots. J. Food Compos. Anal. 11: 305-321.

Low, J., Kinyae, P., Gichuki, S.T., Oyunga, M.A., Hagenimana, V., and Kabira, J.N. 1997. Combating vitamin A deficiency through the use of sweetpotato. Results from Phase I of an action research project in South Nyanza, Kenya. CIP, Lima, Peru.

Omosa, M. 1997. Current and potential demand for fresh and processed sweetpotato products in Nairobi and Kisumu, Kenya. Social Science Dept. Working Paper No. 1997-1. Postharvest Management, Marketing Program, CIP, Lima, Peru.

Purcell, A.E. 1962. Carotenoids of Goldrush sweetpotato flakes. Food Technol. 16: 99-102.

Purcell, A.E. and M.W. Walter, Jr. 1968. Carotenoids of Centennial variety sweetpotato, Ipomoea batatas. J.Agric. Food Chem. 16: 769-770.

Simon, P.W. 1997. Plant pigments for color and nutrition. HortScience 32: 12-13.

Takahata, Y., Noda, T., and Nagata, T. 1993. HPLC determination of β–carotene content in sweetpotato cultivars and its relationship with color value. Japan. J. Breed. 43: 421-427.

WHO. 1995. World Health Organization Micronutrient Deficiency Information System. Global prevalence of vitamin A deficiency. MDIS working paper 2. WHO/NUT/95.3, Geneva, Switzerland.

Table 1. Carotenoids and Vitamin A Values of 17 Sweetpotato Cultivars Evaluated in Kenya, in 1996.

Cultivar	Flesh color	Total carotenoid content* *(mg/100g fresh root ± SD)*	β-Carotene content* *(mg/100g fresh root ± SD)*	β-Carotene-5,6-monoepoxide content *(μg/100g fresh root ± SD)*	β-Carotene to Total carotenoids, *% ± SD*	Vitamin A Value *(RE/100g fresh root ± SD)*
Naveto (CIP440131)	White	< 0.1	< 0.1	1.5 ± 0.3	0.1	0.1 ± 0.0
LM88.002 (CIP188001.1)	White	0.1 ± 0.0	< 0.1	0.1 ± 0.0	4.5	0.9 ± 0.6
KSP 11	White	0.2 ± 0.0	< 0.1	< 0.1	12.5	3.3 ± 0.3
TIS 2534 (CIP440062)	White	0.1 ± 0.0	< 0.1	0.1 ± 0.0	12.1	2.8 ± 0.3
Ex-Diani	White	0.2 ± 0.0	< 0.1	0.1 ± 0.1	10.1	3.2 ± 0.6
Phillippine (CIP440160)	Dark cream	0.2 ± 0.0	< 0.1	0.3 ± 0.2	3.2	0.9 ± 0.3
TIS 70357 (CIP440078)	Cream	0.2 ± 0.0	< 0.1	0.2 ± 0.0	15.8	6.6 ± 1.2
NG 7570 (CIP440377)	White	0.2 ± 0.0	< 0.1	0.1 ± 0.0	9.9	3.4 ± 0.8
Capadito (CIP420053)	Pigmented	0.2 ± 0.0	< 0.1	ND	15.0	6.0 ± 1.0
KEMB 10	Cream	0.4 ± 0.0	0.1 ± 0.0	2.3 ± 0.2	39.6	21.1 ± 1.8
Maria Angola (CIP420008)	Pale orange	0.4 ± 0.0	0.1 ± 0.0	0.5 ± 0.1	28.4	18.5 ± 1.6
Kakamega 4 (SPK 004)	Orange	2.6 ± 0.2	1.5 ± 0.1	68.0 ± 0.0	59.0	258.2 ± 23.3
Zapallo (CIP420027)	Pale orange	4.3 ± 0.0	2.9 ± 0.5	111 ± 19.3	67.7	493.8 ± 80.2
Japon Tresmesino Selecto (CIP420009)	Interme-diate orange	5.5 ± 0.3	4.6 ± 1.4	90.2 ± 2.7	82.7	768.4 ± 228.8
Unknown	Pale orange	7.5 ± 0.7	6.2 ± 0.0	98.5 ± 5.8	83.1	1047.3 ± 15.8
W-220 (CIP440015)	Interme-diate orange	8.4 ± 0.4	6.0 ± 0.5	208.9 ± 56.9	71.7	1021.3 ± 82.1
TIB 11 (CIP440057)	Orange	8.8 ± 0.7	8.0 ± 0.3	91.0 ± 4.7	90.8	1338.2 ± 56.9

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