Case study 6

Diversifying diets: using indigenous vegetables to improve profitability, nutrition and health in Africa

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Introduction

The picture of malnutrition in Africa is quite depressing: 20–25 per cent of the population's nutrient intake falls below minimum dietary requirements, 25–30 per cent of children under five years of age are underweight, 33–45 per cent suffer from vitamin A deficiency (VAD), while a further 30–50 per cent are stunted. There is more than 25 per cent goitre prevalence among 6–11 year olds, 13–20 per cent have low birth weights, and infant mortality rates stand at an unacceptable 5.5–13.5 per cent (Kean et al., 1999). Even more alarming is an 18 per cent rise in the number of malnourished children projected by 2020 (IFPRI, 2001).

Imbalanced diets lead to nutrient deficiencies. Efforts to combat micronutrient deficiencies through biofortification of staple crops or by diet supplementation with vitamins or minerals are relatively expensive and can target only a few nutritional factors. Indigenous vegetables are rich in provitamin A and vitamin C, several mineral micronutrients, other micronutrients and nutraceuticals (Yang and Keding, 2009). Diversifying diets with indigenous vegetables is a sustainable way to supply a range of nutrients to the body and combat malnutrition and associated health problems, particularly for poor households. The relative increased costs of crop diversification would be one-off and minor in relation to the ongoing costs of supplementation through drug treatment or through artificial food additives.

Genetic diversity and health-related benefits of indigenous vegetables in Africa

There are about 400 well-defined plant species encompassing 53 botanical families that are primarily used as vegetables in Africa (PROTA, 2004). More than 90 per cent of these species are either indigenous or ancient introductions to Africa and only 8 per cent are recent introductions regarded as standard global vegetables (PROTA, 2009).

Most indigenous vegetables are collected from the wild, or occur as volunteer plants in crop fields; more recently domestication and cultivation has been on a steady rise (Chweya and Eyzaguirre, 1999; Oniang'o et al., 2006). Amaranth, spider plant, African nightshade (*Solanum scabrum*), African eggplant, vegetable cowpea (*Vigna unguiculata*), and jute mallow (*Corchorus olitorius*) are considered as the most important crop species across communities and borders (PROTA, 2004). The genebank collection of the World Vegetable Center (AVRDC) in Arusha, Tanzania, holds 2,659 indigenous vegetable accessions of 48 species (Table C6.1), the largest in Africa to date. This genebank acts as the primary source of breeding material for the development of new varieties by AVRDC and its partners in the public and private sectors. It is an essential resource for the participatory, farmer-focused variety selection process that AVRDC and its partners have adopted.

High levels of minerals, especially calcium, iron and phosphorus, vitamins A and C and proteins are found in indigenous vegetables (Nesamvuni et al., 2001). These are of particular health value to vulnerable groups such as pregnant and nursing mothers (Table C6.2). Spider plant, roselle and hair lettuce are excellent sources of iron (Weinberger and Msuya, 2004) while African nightshade, jute mallow, and moringa (*Moringa oleifera*) are substantive sources of provitamin A (Muchiri, 2004). Within poor households, approximately 50 per cent of all vitamin A requirements and 30 per cent of iron requirements are provided by the consumption of indigenous vegetables (Weinberger and Msuya, 2004). Spider plant has been reported to retain up to 90 per cent of its vitamin C when boiled (Sreeramulu et al., 1983).

Many indigenous vegetables also contain a variety of nutraceuticals such as allylic sulfides, beta-carotene, flavonoids, genistein, isothiocyanates, limonoids, lycopene, phenolic acids, and phytoestrogens, many of which are antioxidants that prevent or ameliorate disease symptoms. Strong associations between these nutraceuticals and immunity enhancement and prevention of chronic diseases have been reported (German and Dillard, 1998). Indigenous vegetables have been reported to show antioxidant, antiviral, antibacterial, anti-inflammatory and anti-mutagenic activities (Yang and Keding, 2009).

Nutritionally well-balanced diets improve the control of HIV infection and mitigate the health impact of AIDS (FAO, 2002). Chronic malnutrition, especially micronutrient deficiency, has a progressive and synergistic relationship with HIV/AIDS (Beisel, 2001). Early HIV infection is accompanied by certain micronutrient deficiencies (vitamin A and zinc) that play an important role in both the transmission of HIV and its progression (Kean et al., 2001). Improving nutrition thus strengthens the immune system against secondary infection, delays the progression of HIV/AIDS and reduces transmission from mother to child (Kean et al., 2001). Indigenous vegetables have strong nutritional and nutraceutical potential to provide a good interface between food and nutritional security and HIV/AIDS (Gari, 2003). Consumption of moringa, for example, has been demonstrated to improve the health conditions of HIV/AIDS patients by increasing the Cluster of Differentiation 4 (CD4) cells and lowering virus counts (Hirt and Lindsey, 2005).

Table C6.1 A list of the active germplasm collection of strategically important indigenous vegetables preserved and potentially used in breeding at the AVRDC genebank in Arusha, Tanzania

Vegetable Crop	*Genus and species*	*No. of Species*	*No. of Accessions*
Amaranth	*Amaranth cruentus, A. dubius, A. graecizans, A. hybridus, A. hypochondriachus, A. retroflexus, A. shimbuya, A. thunbergii*	9	546
African eggplant	*Solanum aethiopicum, S. anguivi, S. macrocarpon*	3	466
African nightshade	*Solanum americanum, S. chenopodioides, S. cochabambense, S. eldoretianum, S. nigrum, S. nigrescens,S. nodiflorum, S. opacum, S. retroflexum, S. sarrachiodes, S. scabrum, S. villosum*	12	328
Ethiopian mustard	*Brassica carinata*	1	154
Jute mallow	*Corchorus olitorius*	1	35
Hyacinth bean	*Lablab purpureus*	1	51
Moringa	*Moringa oleifera*	1	6
Mungbean	*Vigna radiata*	1	80
Okra	*Abelmoschus caillei, A. esculentus, A. ficulneus, A. manihot*	4	316
Pumpkin	*Cucurbita maxima, C. moschata*	2	77
Roselle	*Hibiscus sabdariffa*	1	297
Spider plant	*Cleome gynandra*	1	107
Vegetable cowpea	*Vigna unguiculata*	1	142
Bitter gourd	*Momordica charantia*	1	1
Ivy gourd	*Coccinia grandis*	1	1
Lagos spinach	*Celosia argentea*	1	1
Marigold	*Tagetes erecta*	1	2
Peas	*Pisum sativum*	1	1
Sword bean	*Canavalia gladiata*	1	1
Velvet beans	*Mucuna pruriens*	1	1
Galant soldier	*Galinsoga parviflora*	1	1
Sun hemp	*Crotolaria* spp.	2	2
Total		48	2,616

Table C6.2 Recommended nutrient intakes (RNI)[a] for women in the first trimester of pregnancy and percentage nutrient intake from 100 g of food[b]

	Protein	*Vitamin A*	*Iron*	*Folate*	*Zinc*	*Calcium*	*Vitamin E*
RNI for pregnant women (1st trimester)							
	60 g	800 μg RE[c]	30 mg	600 μg DFE[d]	11 mg	1000 mg	7.5 mg α-TE[e]
Percentage of RNI from 100 gm food							
Rice	0	0	1	2	4	0	0
Cassava (root)	2	0	1	5	3	2	0
Millet	6	0	2	14	8	0	0
Meat (chicken)	37	0	3	1	14	1	3
Mungbean	40	2	22	104	24	13	7
Vegetable soybean	18	2	13	28	13	4	78
Cabbage	3	1	1	10	2	4	2
Tomato	2	18	1	3	2	1	7
Slippery cabbage	6	106	5	30–177	11	18	58
Moringa leaves	7	146	11	49	5	10	65
Amaranth	9	160	6	31	6	32	17
Jute mallow	10	198	12	21	0	36	36
Nightshade	8	101	13	10	9	21	28
Vegetable cowpea leaves	8	193	6	27	3	54	101

a RNI: data souce: FAO/WHO 2004. RNI for populations of pregnant women (1st trimester) and diets of low iron and zinc bioavailabilty.
b Nutrient data sources: AVRDC nutrition laboratory and USDA nutrient database (USDA, 2010)
c RE: retinol equivalent: 1 μg RE = 6 μg β-carotene α= 12 μg α-carotene
d DFE: dietary folate equivalent, 1 μg DFE = 0.6 μg of folic acid supplement.
e α-TE: α-tocopherol equivalent; 1 mg α-TE = 1 mg α-tocopherol = 1 mg d-α-tocopherol = 0.5 mg d-α-tocopherol.

Linking farmers to markets and marketing indigenous vegetables

Traditionally, indigenous vegetables were grown in homestead gardens for subsistence and rarely traded. However this has changed over the past decade and indigenous vegetables now contribute substantially to household incomes (Pasquini and Young, 2007). This is partly attributed to deliberate market demand creation through concerted promotion and public awareness efforts. Such efforts have been led by staff of Bioversity International allied with local non-governmental organizations (NGOs), rural communities and AVRDC (Moore and Raymond, 2006; Oniang'o et al., 2006; Irungu et al., 2007). Urban consumers now appreciate indigenous vegetables as rich sources of important nutrients as well as traditional flavours, while farmers recognize them as valuable commercial crops. Linking producer groups to market outlets in both formal and informal markets has led to a shift in production trends particularly in Tanzania, where an estimated 70 per cent of the vegetables grown and marketed in rural and peri-urban areas are indigenous vegetables, while in Kenya a 135 per cent market growth for these vegetables was realized between 2002 and 2006.

Promoting the consumption of indigenous vegetables

AVRDC employs an inclusive participatory approach to variety development that involves joint evaluation and demonstration with various stakeholders. This approach ensures the continual flow of information from farmers and consumers to researchers and back to farmers for the identification of new varieties that meet market/consumer demand. The new varieties are promoted through demonstrations, field days, seed fairs, information leaflets, distribution of seed kits for home gardens, training programmes for farmers, and workshops in collaboration with seed companies, NGOs, and National Agricultural Research and Extension Services (NARES). For example, in partnership with Farm Concern International, AVRDC and Bioversity International have introduced and promoted new lines of various indigenous vegetables in Kenya and Tanzania, successfully competing with standard vegetables in supermarkets. Currently, several supermarkets in Nairobi have attractive displays of indigenous vegetables while some restaurants, such as Ranalo Foods, now specialize in indigenous vegetables and other traditional foods (Moore and Raymond, 2006).

African eggplant as an indigenous vegetable with potential for rapid development

The genus Solanaceae comprises more than 3,000 species. Globally, it is among the most important taxon economically and is the most valuable in terms of vegetable crops (Mueller et al., 2005). These species have evolved in highly contrasting environments, and, although vegetable crops such as potato

Figure C6.1 African eggplant: In the process of domestication, *Solanum aethiopicum L.* developed into four cultivated groups based on adaptation to different growing conditions and selection for either fruit or leaf consumption. The Gilo group, shown here, has edible oval or round fruit 2–12 cm long ranging in colour from white, green, red, brown to purple. The Shum group has small hairless leaves, which are consumed as a leafy green; the small, very bitter fruit is not eaten. The Kumba group produces large ridged fruit (5–10 cm in diameter) edible when green or red in colour, and has large leaves that can be consumed as a vegetable; some cultivars of this group are used for both fruit and leaf consumption, while others are mainly grown as leafy vegetables. The furrowed fruit of the Acelatum group is about 3–8 cm in diameter (Grubben and Denton, 2004; Porcher, 2010). Source: AVRDC – The World Vegetable Center

and tomato are reasonably well understood and may be regarded as 'model' species for research, the majority of the potential vegetable species within the genus remain largely under-researched, if not undiscovered. In the case of the 'aubergine' or eggplant (*Solanum melongena*), its worldwide prominence in Mediterranean agricultural environments has led to a long history of cultivation and substantive research support, mostly for purple coloured teardrop shapes or their near equivalent. This is less true for other shapes and colours of *S. melongena*. Three of its near relatives, the African eggplants (*S. aethiopicum*, *S. anguivi*, and *S. macrocarpon*) have received very little research attention, yet these species have potential for helping smallholder farmers grow themselves out of poverty.

African eggplant is commonly grown and consumed in the tropical areas of sub-Saharan Africa, South Asia and Southeast Asia. The fruit varies in shape from round, ovoid, or teardrop to long and thin; colours include white, yellow, green, orange, brown, and speckled. The flesh can be sweet or bitter in taste. The usual locus of production today is from smallholder growers or from kitchen garden plots, and farmer use of improved or hybrid seed is rare (Keding et al., 2007). The lack of a preferred market type and production on small farm plots provides little incentive for seed companies to invest in improved types, as each market segment is perceived to be comparatively small and ill-defined. This, in essence, is the research and development problem associated with this species. Nevertheless, African eggplant is popular and could generate much broader demand from urban populations in Africa and Asia with sufficient research and development investment.

Identification of the dimensions of the research and development problem for African eggplant

Accurate statistics on the area of land under production and the productivity of African eggplant species worldwide are essentially unavailable (FAOSTAT, 2007). This is a truism for most vegetable species not only at the global level, but also at regional and down to national levels. This is probably because such a crop is deemed by statistical collection authorities to be largely of smallholder interest only, as much of the crop is self-consumed by producer families with only the excess sold fresh in local markets. Data on vegetables are perceived as less important and more difficult to collect from smallholders or low-volume market traders than for staple crops traded internationally, such as maize and rice. Yet these species are available for sale, though in small quantities, throughout sub-Saharan Africa, South and Southeast Asian, whether it is in the Sahel, the Great Lakes, the Deccan or the Mekong regions (Chadha and Mndiga, 2007; National Research Council, 2006).

National authorities, private sector seed companies, and public sector breeders in most parts of the tropical world have shown ambivalence toward these eggplant species, with the exception of India, where many eggplant types are grown. Until recently, improved seed has not been available in most countries and only unimproved landraces have been the principal sources of seed. Research in general has been minimal, as reported by Ssekabembe and Odong (2008). In Uganda, more recently, Oluoch and Chadha (2007) have shown that of 42 lines of African eggplant, the highest five-year mean fruit yields could exceed 62 t/ha, with seed yields also above 2 t/ha. In comparison, previous yields using landraces might have been around (*Solanum scabrum*) 5–20 t/ha (Oluoch and Chadha, 2007). These authors showed that *S. aethiopicum* lines were better adapted to conditions in Arusha, Tanzania than *S. anguivi* and *S. macrocarpon*. There were considerable differences between lines, suggesting good opportunities to select superior cultivars.

In addition to good yield potential, it is evident that the eggplant, though not particularly nutritious itself, can be grown as an intercrop with nutrient-dense green leafy vegetables such as *Amaranthus* spp. Examples from Uganda suggest this is a more profitable option than sole cropping of either vegetable (Ssekabembe, 2008).

Figure C6.2 An African eggplant of the Kumba group. African eggplant fruit is eaten boiled, steamed, pickled or in stews with other vegetables and meats. Young leaves of African eggplant are high in beta-carotene and calcium. Source: AVRDC – The World Vegetable Center

The approach of AVRDC to research and advocacy for African eggplant

AVRDC – The World Vegetable Center has committed breeding and full value chain support to African eggplant. The Center seeks to provide improved varieties of different African eggplant species for release throughout sub-Saharan Africa and South and Southeast Asia. These are types deemed desirable by consumers in tropical regions for colour, shape, and taste. The Center also encourages national seed release and control authorities to make registered quality seed available to farmers. Small- and medium-scale private sector partners were encouraged to multiply seed of improved African eggplant lines and sell it directly to farmers, or to use the improved lines as parents in their own breeding or hybridization programmes.

Research and development results to date of AVRDC and its partners

Current research and development has resulted in the release of several AVRDC African eggplant varieties in Africa. In Mali, 'Soxna' produces flattened, lobed fruit turning red-orange at maturity; it has a slightly soft texture and can be eaten fresh or cooked. Variety 'L10' has slightly smaller fruit of similar characteristics. In Tanzania, variety 'DB3' has been released; it has white, medium-sized, ovoid, sweet fruits. This line is already popular with farmers, and demand for seed exceeds supply. Seed of 'DB3' will be sold by small and medium seed companies throughout Tanzania's Great Lakes Region. Other types of African eggplant will soon be available from AVRDC's breeding pipeline.

Impact on farmers and their families

Chadha and Mndiga (2007) report that several promising varieties of African eggplant were identified in Arusha, Tanzania including 'DB3', 'Tengeru White', 'AB2' and 'Manyire Green.' Seeds were distributed to 200 farmers in the Arumeru district of Tanzania (near Arusha) and an informal survey was carried out with those farmers who had collaborated in the test-growing. These farmers were generally smallholders and were able to allocate about 0.5 ha or less to growing eggplant in a single season. 'DB3' and 'Tengeru White' seemed to be the preferred types, and 'DB3' was formally released in 2011.

There was high market demand for these crops locally and incomes were said to have increased by between US$1,600 and US$2,500 per hectare per season. Farmers reported several substantial social improvements as a result of the increased income, including the ability to purchase more land, build houses, and buy improved household articles. One grower is also acting as a consolidating buyer, employing women to harvest, sort, grade and bag the crop prior to sale to local wet markets or supermarkets.

Marketing efforts to interest supermarkets in African eggplant in Tanzania and Kenya have been successful, and the fruit is now commonly seen for sale in Nairobi, Arusha and Dar es Salaam, as well as in Accra, Cotonou and other cities in West Africa (AVRDC, 2008). Most consumers in big African cities have a desire to purchase the indigenous vegetables that are more common in rural areas. This appears to be the case for African eggplant and market demand remains buoyant.

What further research is needed?

Early tests of the economic performance of improved eggplant seed have shown that African eggplant can be a profitable crop provided consumer preferences are addressed in improved varieties. However, suitable seed systems need to be developed and seed must be made available throughout countries in the tropics to adequately address the crop's potential. The complexity of ploidy relationships in intercrosses between eggplant species needs better understanding if hybrid seeds are to become more easily available. There have been some levels of success with new intra- and interspecific pipeline hybrid varieties developed by Rijk Zwaan Afrisem Co. Ltd in Arusha Tanzania (H. Peeters, pers. comm., 2010).

Little is known about the agronomy of pest resistance of the improved varieties, although evidence exists that *S. aethiopicum* has substantive resistance to bacterial wilt (*Ralstonia solanacearum*). This is seen to be of considerable value globally as *S. melongena* is generally lacking resistance to this serious and common disease (Colonnier et al., 2001). Evidence is needed to determine whether heat and drought tolerance claims can be substantiated in reality.

Lessons learned and future prospects

Indigenous vegetables were previously considered subsistence food crops as opposed to cash crops. It is now established that they attract good prices in local markets and also have potential for international trade. Among the food crops, starch crops are referred to as staple or food security crops and indigenous vegetables fall into the category of non-staple crops. Yet, indigenous vegetables often accompany staple crops in meals, and most staple crops are less palatable without associated vegetable servings. Indigenous vegetables can enhance bioavailability of micronutrients in staple crops and promote absorption (Vijayalakshi et al., 2003). In addition, some indigenous vegetables can be harvested in just 21 days, providing a rapid response to urgent needs for food and nutrition, while most of the food security crops take at least six to nine months to reach harvest. It is now recognized that food security cannot be delinked from nutritional security, to which the consumption of indigenous vegetables significantly contributes (Keatinge et al., 2011). Well-balanced diets are essential to human health and these are best achieved by greater diet diversity and increased consumption of vegetables. Continuing investment in indigenous vegetables research and development is thus a vital weapon in the continuing battle against human malnutrition worldwide.

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