CHALLENGE THEME PAPER 4: SWEETPOTATO VALUE CHAINS

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Overall Challenge: How do we improve the value chain for sweetpotato given its bulky nature, undiversified use, and image as a poor man's food?

BACKGROUND

Sweetpotato roots are bulky and perishable unless cured. This limits the distance over which sweetpotato can be economically transported. Production areas capable of generating surpluses tend to be relatively localized but dispersed, which leads to a lack of market integration and limits market size. Moreover, production is highly seasonal in most countries leading to marked variation in the quantity, and quality, of roots in markets and associated price swings. There is little commercial processing into chips or flour, which could be stored for year round consumption for use in ugali, bread and cakes, or processing into fermented and dried products like fufu. Sweetpotato consumption tends to decline as incomes rise, a change often linked with urbanization, partly because it is perceived as a "poor man's food" but mostly because of the change in relative prices of root crops compared to grains in urban areas due to transport cost differentials.

Addressing this challenge means improving the sweetpotato value chain, understood as including all the actors from input suppliers (appropriate varieties, vines) to farmers, traders and consumers (Figure 4.1). More broadly the value chain also includes a) the institutions or regulatory framework which structures the way in which transactions occur in the chain and b) the service providers, including research and development organizations, who help to improve its functioning. A value chain approach means more than looking at markets. It includes changes in seed and production systems to improve the value added in market, implying strong linkages with crop management. Quality is often a key factor determining entry into urban markets and root quality starts with appropriate crop management techniques. It seems likely that significant changes in crop management will only occur where farmer investment and intensification are justified by improved market prospects.

This Challenge essay also includes post harvest processing or storage. This can lengthen the period for which sweetpotato can be marketed but may also be relevant for subsistence oriented households to increase the period over which sweetpotato can be consumed, particularly where there is a marked dry season.

As we will discuss later, because of its novel attributes and potential for improving nutrition, orange-fleshed sweetpotato (OFSP) presents particularly interesting prospects for market development.

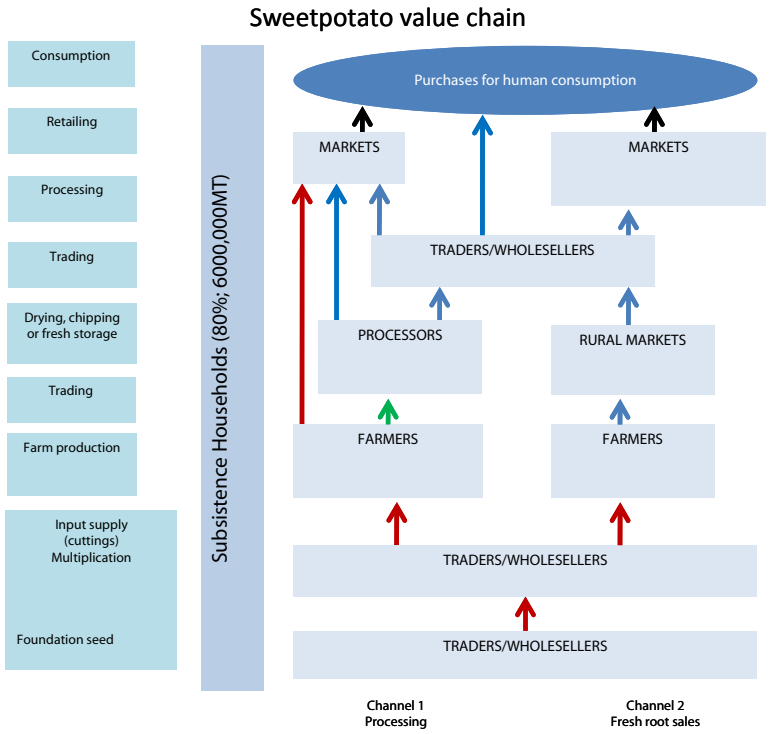

Figure 4.1
Sweetpotato value chain.

Improving the sweetpotato value chain should lead to a linked set of impacts on the livelihoods of the poor including:

1) Increased income of those selling sweetpotato with particular advantages for women who often take the lead in managing this crop.
2) Reduced expenditure on food of those purchasing sweetpotato roots or processed products; and
3) Enhanced nutrition for those producing and purchasing sweetpotato (especially OFSP).

Since sweetpotato is grown extensively by poorer rural households and in many parts of Sub-Saharan Africa (SSA) is managed by women, market chain development of the crop naturally "targets" poor rural women and their households. Sweetpotato market chain development will require a gender-sensitive approach to monitor intra-household control of resources dedicated

to or coming from sweetpotato production and commercialization. From such understanding strategies for assuring gender equity can be devised.

PRINCIPAL CHALLENGES

Challenge 4.1. Limitations of size for sweetpotato markets

Current knowledge

Sweetpotatoes are principally grown in food systems in SSA dominated by root crops and bananas/plantains and secondarily grown in maize-based systems. Sweetpotatoes are a strategic and flexible part of these food systems. Early maturing varieties of around three months are first to come into production to end the "hunger season" and these are often improved materials. Due to their flexible planting times and range of maturity periods farmers can manage the supply period if not constrained by an extended dry period. This helps ensure continuity of staple food supply, both for home consumption and market, so that producers can take advantage of generally higher staple food prices early in the growing season. In the root crop belt of West Africa sweetpotatoes complement the supply periods of cassava and yams, the two principal crops in those food economies. The interacting roles and development potential of the different root crops in West Africa are compared in Table 4.1.

Table 4.1. Comparison of different root crops in the food economies of Coastal West Africa.

	Cassava	**Yam**	**Orange-fleshed Sweetpotato**	**White-fleshed Sweetpotato**
Importance	Very high	High	Low	Medium
Productivity	Very high	High	Low	Can it compete with cassava?
Preference	Mass Consumption Gari	Mixed processed and fresh, festive food	Niche crop Fresh, Potential	Niche, fits in system in seasonal way
Producers	Commercial	Mixed	Village level	Village level
Research issue	Industrial quality	More commercial system	Quality, Taste, Dry matter to develop market	Productivity, Market chain in competition with cassava, yam
Seed system	Relatively simple	More difficult	Dependent on vines and water	Dependent on vines and water throughout year
Uptake/Upscaling	Market-led	Local	Institutional, school feeding, relief programs, and local procurement for institutional programs	Move from village niche to market system
Link to Goal	Income, the pathway out of poverty for producers	Limited growth of preferred food fighting change in consumption habits	Develop consumption, make it preferred good, raise productivity, create vine system	Income, eventual industrial use

In countries with two rainy seasons (for example, Rwanda, Burundi and Uganda) sweetpotato is available 11 months of the year and is a primary staple. Elsewhere in SSA, where there is only one main growing season, sweetpotato is available 4-8 months of the year and it is a secondary staple (Low and van Jaarsveld, 2008). Marketable surpluses are seasonal and come from more specialized production zones. It is not economically feasible to transport sweetpotato from distant locations or from areas with poor road infrastructure (Hall *et al.*, 1998). Farmers in less favored locations often report that marketing sweetpotato is difficult; either markets are too distant using local transport or farmers are forced to be price takers of a sole trader serving the area. The risks of oversupply are greater in rural locations distant from significant urban populations, as reported in Rwanda and elsewhere, so that when harvests are heavy no market exists for extra production (S. Karitanyi, personal comment 2008).

Discontinuous supply from relatively specialized production zones, high transaction costs (see Challenge Paper 5) and the bulky and perishable nature of the root leads to relatively high marketing costs, increasing prices to urban consumers. In some rural areas in Eastern and Central Africa, sweetpotato is heavily consumed (annual per capita consumption of over 80 kg). In most other rural areas, it is a secondary staple consumed 2-4 times per week when in season. Boiled and steamed roots often serve as a breakfast food. With the exception of some cities such as Kampala (Uganda), sweetpotato plays a more limited role in urban diets, often as a breakfast or snack food. Anecdotal reports suggest that it is perceived as an inferior good or "poor man's food" (Wheatley and Loechl, 2008; GTZ, 1998). Some consumers report not liking to eat much sweetpotato as it can cause flatulence (due to undigested and dietary fiber). The degree to which cooking controls the flatulence varies by cultivar (Tsou and Yang, 1984) and improved techniques are needed to evaluate this negative varietal characteristic. Whilst many observers agree that sweetpotato has become more important in urban markets, with its use as a bread substitute being particularly important, this has not been clearly documented. In general, there is a dearth of precise information about the consumption of sweetpotato. One study from Rwanda (Figure 4.2) shows how consumption of sweetpotatoes is substantially lower in urban areas and falls with increasing income, confirming that here it is an inferior good in urban areas (DeWalt, 2007).

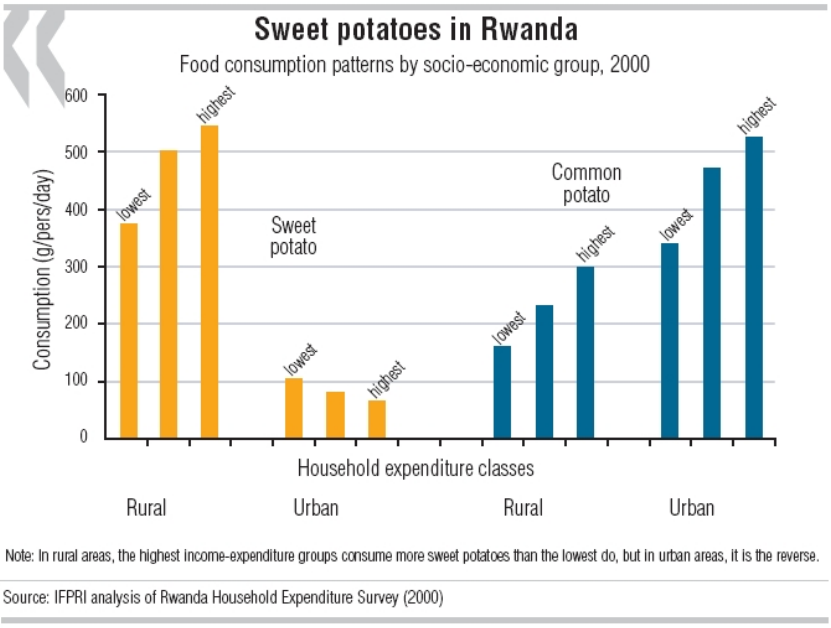

Figure 4.2
Food consumption patterns of potato and sweetpotato by socio-economic group in Rwanda

The dispersed and seasonal nature of sweetpotato production, high costs of marketing (lack of processing opportunities), competition with other staples, the periodicity in the diet and limited consumption in towns, lead to low volume or "thin" urban markets in those SSA countries where it is a secondary staple. This limits the adoption of productivity enhancing technology as additional supply leads to sharp price falls. This expectation may choke off production increases or technology adoption. The multiple causes of thin markets means that there is no single critical entry point into sweetpotato value chains that would release a transformation of production and consumption. Any such transformation would have to take place across the value chain.

The promotion of orange-fleshed sweetpotato (OFSP) or diversified use into processed products (this strategy is discussed in Challenge Paper 3) could potentially drive such a transformation of the value chain. Both strategies rely on the development and marketing of a new product. An alternative or complementary strategy would be to extend the supply period through the year (this strategy is discussed in Challenge Paper 2), either through storage or extension of the production period.

A market transformation strategy based on the introduction and promotion of OFSP will need to be adapted to the very different market contexts for sweetpotatoes across Africa. Three relatively broad contexts are characterized in Table 4.2. In both West and East Africa, OFSP will have to

break into markets with strong existing preferences, for example, for highly preferred high dry matter, white or yellow-fleshed varieties, in most of these two regions. In the Southern African context, the challenge is to build market demand where sweetpotato is consumed seasonally as a secondary staple and there are no strong preferences at present, as is the case in Mozambique and particularly in countries emerging from conflict. Experience from pilot projects in Mozambique suggests that the second context will be less problematic for market penetration of OFSP (Low *et al.*, 2005).

Table 4.2. Comparison of market contexts for introduction of OFSP in different African sub-Regions.

	West Africa	**East Africa**	**Southern Africa**
Consumer Preferences	High Dry Matter Poundability	High Dry Matter	No Strong Preference
Sweetpotato (SP) Market Penetration: ▪ **Local Market** ▪ **Urban Market**	High Low	High Medium	Medium Low
Continuity of Supply	Different Root Staples	Varies in Different Production Regions	Seasonal

Many projects and research and development organizations have enthusiastically promoted OFSP in communities in SSA, and especially in Mozambique, Uganda, Tanzania, Kenya and Rwanda. This has led to considerable adoption in pilot communities and increased consumption of OFSP amongst the rural families involved, and in Mozambique, health impacts have been demonstrated (Low *et al.*, 2007). As of 2008 very limited quantities of OFSP were reaching urban markets in Uganda, Tanzania, and Rwanda; more in Kenya. Some market traders had seen OFSP roots in these countries but few were apparently aware of any nutritional benefits and often they would mix them with white and yellow roots so that they could be sold. There was no evidence of any price premium for OFSP in this group of countries, and sometimes OFSP incurred a price penalty when traded. The exception was Mozambique where in the Gurue market in 2007, OFSP was selling in separate piles at about a 20% premium over white fleshed sweetpotato (Thiele visit report) and in areas of Zambézia with very limited purchasing power OFSP sold faster (Low *et al.*, 2005). Here radio campaigns and work with market traders had successfully shifted consumer perceptions generating this premium. This provides proof under these market conditions that demand creation can effectively differentiate OFSP from white fleshed sweetpotato and generate a price premium.

As a new product in urban markets, OFSP has unique visual and health attributes for consumers which offer potential for brand identification. This could be reinforced by supplying markets with higher quality roots and possibly grading. Introducing OFSP varieties alone has limited potential for success. Rather, introduction must be associated with adjustments through the value chain, driven by awareness and demand creation associated with improved health status for consumers. If demand can be created for a high quality product, there is potential for a price premium emerging compared to white fleshed sweetpotato, further motivating farmer adoption of OFSP varieties.

Demand creation should look for particular market entry points. It could start with nutritional education in school feeding programs or with changing product perceptions at the high end of the market, through promotion in supermarkets which are rapidly expanding in cities in SSA. The latter option is being tested in Kenya and Tanzania, combined with supplies of indigenous African vegetables, both of which focus on improved nutrition. This promotion as a vegetable among high-income consumers has the potential to spill over into urban markets supplied through the traditional wholesale markets. In Mozambique, painted market stalls, signs on buildings, decorated cloth for women, radio programs, community theater, and training traders to market OFSP are employed to create awareness of OFSP's nutritional qualities and build demand for purchase.

Demand creation should be based on an understanding of the role of sweetpotato in food systems. In Central and East Africa there is often a cultural perception that sweetpotato is a "sweet" food most appropriate for women and children. This creates a natural link to some of the most vulnerable groups for a nutrition intervention around OFSP but is a possible barrier for wider market penetration. Similarly, adults prefer high starch content varieties, while children prefer the softer, lower starch roots.

Areas for future work (not necessarily in order of importance):

1) Study urban and rural markets to understand volumes, preferences and market structure for SP and OFSP.
2) Identify specific market opportunities where increased production could be absorbed e.g. OFSP in school feeding programs.
3) Analyze role of SP and other staples in urban diet and cultural perceptions of different foodstuffs in order to change product image and consumer behavior.

4) Develop campaigns for urban consumers to shift perceptions and develop new product concept of OFSP as a healthy, visually attractive and "modern" foodstuff.
5) Develop and test strategies for market penetration of OFSP in different market contexts.

Challenge 4.2. Perishability and availability

Current knowledge

In most places in SSA there is a marked dry season and sweetpotato is only produced part of the year. Roots are perishable, and unless cured or placed in stores, will likely not be marketable 1-2 weeks after harvest. Market traders in Nairobi and Kampala reported selling consignments within 3 to 4 days after arrival before rotting occurs (Omosa, 1997; Hall *et al.*, 1998).

Roots can be stored in the ground for an additional period but they are attacked by weevils when soil is dry and cracked. This leads to a marked seasonality of supply with substantial price variability and deterioration in quality as the dry season progresses. Seasonality of supply creates a barrier to increasing per capita consumption and income earning possibilities both for fresh sales and for processing. There are some places, such as Rwanda, where production occurs in wetlands outside the rainy season and seasonality of supply is less marked.

Farmers have developed "In ground storage and piecemeal harvesting" technology to maintain the supply of fresh sweetpotato for as long as possible (Hall *et al.*, 1998). In Uganda this involved:
Staggered planting, so that crop will not all mature simultaneously.
Menu of varieties with different characteristics including maturation time to make fresh sweetpotato available over a longer period and provide roots with different post harvest characteristics e.g. yield, in ground storability and taste.
In ground storage of roots after maturity, for up to six months.
Piecemeal harvest of roots needed for immediate use.

Piecemeal harvesting is an indigenous practice which may reduce weevil losses as more superficial and potentially damaged roots are harvested first (Smit, 1997). Some work has been done on integrated pest management (IPM) to extend the cropping season and lengthen the period of in ground storage (see Challenge Paper 5 on Crop Management).

Farmers in areas with marked dry seasons in Uganda and Tanzania sun dry sweetpotato to extend the period when it may be consumed. In Uganda, roots are sliced (*amokeke*) or crushed (*inginyo*) before drying (Hall *et al.*, 1998). *Amokeke* is reconstituted whole as a breakfast food and *inginyo* used for flour to produce atapa, a starchy staple. In Tanzania roots are sliced fresh (*vichembe*) or

after boiling (*matoborwa*) before drying. These products can be stored for six months in Uganda, and perhaps longer in Tanzania. Attack by insects limits storage period. Artisanally dried products are mostly used for home consumption with limited commercialization, probably because they are not competitive with dried cassava chips. Slicing and drying by hand is labor intensive for processing large quantities when fresh storage would be preferable, but is an option for dealing with small quantities at a time.

If farmers could store fresh roots they could benefit from higher prices at the end of the harvest season. In practice there is little use of pits, clamps (mounds of sweetpotato sealed with earth to maintain humidity and keep out pests) or other types of stores in SSA; Malawi is an exception, although these are used in other parts of the world (Hall and Devereau, 2000). Research by the Natural Resources Institute (NRI) on low cost storage using pits and clamps with thatched roofs showed that storage up to 4 months is possible. Stored roots are fit for home consumption but sell with a price penalty or may not be marketable because they lack the "just from the garden look" which consumers expect in fresh products (Hall and Devereau, 2000). Low cost storage was validated by NRI in Tanzania. Adoption of stores for commercial use depends upon the expected price difference between the time of harvest and the moment of sale and this is variable across and within countries. A much higher price out of season was encouraging adoption of storage in Tanzania in 2004 (RIU, 2007). A cost benefit analysis of stores for home consumption in Uganda showed much higher rates of return than for any other sweetpotato enterprise (Wheatley and Loechl, 2008).

Sweetpotato roots respire during storage, but this can be reduced by curing. Curing sweetpotato roots at about 29ºC with high humidity for four-seven days prior to storing at 12-14ºC is used commercially in the United States to heal wounds, protect against disease, reduce shrinkage and extend storage (Kemble 2004). High ambient temperatures may mean that this type of curing is not applicable in SSA (Hall and Devereau, 2000). NRI has tested pre-harvest curing by removing sweetpotato foliage 14 days before harvesting, which reduced post harvest losses by up to 40% (RIU 2007). Breeding is possible to improve storability as shelf life is a varietal characteristic, but it appears that cultivars that lose weight rapidly rot more (Rees *et al.*, 1998).

Areas for future work:

1) Work on improving in ground storage together with IPM to extend availability of white/yellow fleshed SP and OFSP in areas with reasonable market access and sufficient levels of productivity to be competitive in urban markets (linked with Challenge Paper 5)

2) Participatory research and economic analysis of curing and low cost storage in market related pilots (linked with understanding seasonality of supply and price premium associated with out of season production).
3) Varietal development to offer most diverse set of harvesting periods with broad array of post harvest characteristics (linked with Challenge Paper 1).

Challenge 4.3. Processed sweetpotato products are mostly unknown in Sub-Saharan Africa

Current knowledge

Sweetpotato is a bulky and perishable root. If it could be converted into processed products this could increase consumption by allowing it to be transported further and stored longer. An increase in the size of the market would also create new income earning possibilities and add value for farmers. Processed sweetpotato products targeted at higher income groups and promoted with brand identification would help break the image of sweetpotato as a poor person's crop.

But, as far as could be judged from field visits and a review of the literature, neither locally nor improved processed sweetpotato products of white/yellow or orange fleshed sweetpotato are of any real commercial importance on a large-scale at the moment. Many pilot initiatives selling sweetpotato processed products exist, particularly in Uganda, Kenya, and Mozambique, on a limited scale. OFSP flour is being marketed in supermarkets in Nairobi.

The past year has seen marked rises in the prices of internationally traded grains, which are likely to be sustained, although probably at somewhat lower levels than present. Wheat and maize prices for grain and flour have increased in many SSA countries as a result. Sweetpotato is not traded internationally and surveys in many markets suggest that its price has not increased so sharply. This makes sweetpotato relatively more competitive compared to wheat, assuming this compensates for other cost disadvantages in the supply chain.

In countries with two rainy seasons (Rwanda, Burundi and Uganda) sweetpotato is available most of the year. In most other SSA countries it is not available during much of the dry season, limiting the period of consumption. This gap has stimulated research on the consumer acceptability, nutritional value and the enterprise viability of a variety of processed sweetpotato products, which are discussed below.

Sweetpotato can be chipped and dried. At the village level, women slice the sweetpotato into thin round chips by hand. Commercially oriented operations require an investment in chippers, with manual, bicycle driven and motorized versions available, and drying racks. Analysis of a pilot initiative in Uganda indicated that chipping with white SP varieties was not financially viable (Wheatley and Loechl, 2008). Dried chips can be milled to make sweetpotato flour. This adds more value for farmers, and reduces volume for transportation, and was financially viable in a pilot trial. But it is difficult for farmers to maintain quality (a) because they cannot determine moisture content and may mill chips which are not properly dried and (b) it may contain impurities as farmers use public mills (Wheatley and Loechl, 2008).

The largest flour market is for staples such as ugali. White fleshed sweetpotato flour would have to compete on price and quality with cassava and maize flour in this market. Since fresh sweetpotato tends to sell at a higher price than cassava this could be difficult. In addition, in East Africa sweetpotato flour was less acceptable for some staples; for example, consumers did not prefer sweetpotato ugali because of its sweet taste (Omosa, 1997 reported in Wheatley and Loechl, 2008). In East Africa, it appears that the clearest market for sweetpotato flour would be as a substitute for wheat flour in the production of the snack foods, chapattis (flat unleavened bread) and mandazi (doughnuts) and porridge, where sweetness is not an issue. In Kenya, a processor chain began in 2005 that consists of one contact farmer, one miller and a distributor (Touchstone) which supplies the OFSP flour to Uchumi supermarkets and other markets in Nairobi. The contact farmer buys OFSP (preferring medium-sized roots of the Ejumula variety) from other farmers, from which he makes chips. He then delivers the chips to the miller who makes OFSP flour and packs and delivers it to the distributor, who is based in Nairobi. The flour is packed in half kilogram bags (Kaguongo, 2007). In 2007, farmers were complaining that the price being offered was too low compared to the price for fresh roots and often supply the contact farmer with roots of secondary quality, selling first quality roots on the local market. The OFSP flour marketed in Nairobi is targeted at higher income consumers for these purposes and is located in the specialty flour section in supermarkets.

Owori and Hagenimana (2001) reported several factors that might limit adoption of sweetpotato as a raw material: sweetpotato flour is of a lower quality than wheat flour, and bakers, who are used to managing and storing dried ingredients, reported that washing, peeling and boiling sweetpotato required too much labor time. The seasonality of supply of fresh roots could be a further problem for bakeries, although less so in countries such as Rwanda where there is more dry season production. Experience with other composite flours in Africa suggests that flour

mixing is not viable at the mill level but rather at the bakery. However, organizing value chains for sweet potato flour are organizationally complex when compared to mills located in urban areas grinding imported wheat.

In tests with consumers, boiled and mashed sweetpotato gave products with the highest consumer acceptability, and snack sellers reported that they could sell these for the same price as those made solely from wheat flour (Hagenimana and Owori, 1997 reported in Wheatley and Loechl, 2008). Bread made with fresh mashed sweetpotato was preferred by consumers to bread made only from wheat flour. Sweetpotato as flour or mashed lowered costs and increased the net revenue of snack food sellers and bakers. Mandazi made with mashed sweetpotato absorbs considerably less oil (an expensive ingredient) than those made with wheat flour alone (Hagenimana *et al.*, 1998).

OFSP either mashed or as flour potentially offers a new set of attributes which could make sweetpotato based processed products more competitive. Improved nutritional characteristics because of beta-carotene and an attractive orange color mean that sweetpotato could command a price premium and break out of direct price competition with alternative flours. Links have been created with millers and OFSP has been supplied to make sweetpotato flour in Nairobi and a composite flour for porridge in Kampala (Wheatley and Loechl, 2008; Horton, 2008).

Consumer research has shown that some food products containing OFSP such as golden bread are of good quality and acceptable to consumers, especially children. Studies of flours and other processed products indicate that provided high beta-carotene varieties are used and chips are stored for less than four months, Vitamin A levels remain sufficiently high after processing for these products to make a significant contribution to Vitamin A deficiency (Bechoff *et al.*, 2008a; Bechoff *et al.*, 2008b).

Consumer taste tests in a market in Mozambique showed a strong preference for golden bread made with boiled and mashed sweetpotato (38% of weight of wheat flour) over conventional white bread because of heavier texture, superior taste and attractive golden colour. A 110g bun would provide 45% of the Vitamin A requirement of a three year old child. Profits when baking golden bread increased by 54 to 92% because sweetpotato had a much lower cost than expensive imported flour. At rural locations where wheat flour is at least 1.5 times more expensive per kg than fresh sweetpotato, the cost advantage of OFSP is higher. For rural bakers, boiling and mashing sweetpotatoes was not seen as a problem but urban bakers with larger

volumes might need specialized equipment (Low and van Jaarsveld, 2008). The major constraint is assuring sustained supply of roots to bakers. Research is on-going in Mozambique to improve the bread value chain. In addition, there could be concerns on the part of bakers on meeting quality standards (G. Sina, personal comment 2008).

OFSP has also been used for making niche products including juice and sweetpotato crisps. OFSP juice requires the addition of citric acid, it is readily accepted by consumers and a snack shop in Mozambique sells it on a commercial basis. OFSP crisps have been piloted by a commercial company in Kampala (Horton, 2008). These products are targeted at higher income groups and can serve a similar function of changing the image of OFSP and stimulating wider consumption. Lessons could be learned from similar programs such as CIP's through Papa Andina Initiative which promoted native potatoes in the Andes building on unique attributes of attractive visual appearance and Andean origin. Here, promoting niche products, with low volumes, such as chocolates made with dried potato, helped shift consumer perceptions of native potatoes as a poor man's food. Promotion of the use of niche products like OFSP juice could have a similar function in SSA.

Sweetpotato is sometimes mentioned as a source of starch. But this is unlikely to be a commercially viable venture in SSA because sweetpotato starch here lacks any compelling functional advantage over alternative sources and raw material costs are relatively high (Wheatley and Loechl, 2008).

Areas for future work:

1) Develop a strategy for increasing consumer demand for sweetpotato and especially OFSP building on its unique attributes. This requires the development of general product concept for OFSP based processed foods relevant for the particular country setting and target group.
2) Develop approach for scaling up golden bread production which addresses hidden costs of shifting from use of dry ingredients to fresh roots and quality concerns.

Challenge 4.4. Limited coordination among actors in sweetpotato value chain

Current knowledge:

Sweetpotato is usually transported relatively short distances because of its bulky and perishable nature. This leads to the emergence of geographically distinct supply chains, with particular arrangements of market chain actors, distinct varietal preferences and sets of linked service

providers. For example, the Dar es Salaam market preferences are for white skinned varieties whereas in Mwanza the preference is for red skin.

The value chain begins with vine producers. Specialized vine producers are not common in SSA, and farmers ordinarily produce their own vines. Farmers supplying urban markets are often located in areas with some specialization in sweetpotato, although they continue to be relatively diversified. Commercial cultivation of sweetpotato with larger plots intended primarily for sale is exceptional. In Uganda, larger farmers are found on main roads in Soroti and Kumi serving Kampala and other major provincial cities. (Hall *et al.*, 1998). South Nyanza district in Western Kenya has large scale production to address year-round demand in Nairobi and a peak demand period for Ramadan in the coastal areas.

Private brokers or middlemen often purchase sweetpotato in production areas with a more commercial orientation. They agree prices, amounts and time of harvest with producers and may harvest and bag to ensure quality. They assemble truck loads from numerous small farmers located in what are usually diversified, smallholder systems. This leads to high transaction costs. Transport costs along poor roads may take up a large percentage of the margin between farm gate and wholesale price. One study in Uganda found that brokers made a profit of 5% of the farm gate price (Hall *et al.*, 1998).

A study in Uganda found that packing, handling and filling of sacks used to transport roots to urban markets can be rough, contributing to physical damage. Forcing roots into overfilled sacks with an extension so that a 100kg sack can hold 120kg further increased the probability of scuffing and cuts. The use of overfilled bags in Uganda was linked to taxes, market dues and handling charges being made on a per bag basis. Despite this treatment the study concluded that contrary to popular belief physical losses in the marketing chain were low (Hall *et al.*, 1998).

Larger cities in East and Central Africa sometimes have larger markets assuming a wholesale function, where whole bags are sold to retailers who operate in the same market or elsewhere. Trade in wholesale markets in Dar es Salaam is controlled by commission agents, who broker transactions between assemblers and retailers and charge a flat rate per bag (RIU 2007 and G. Ndunguru personal comment). This structure often limits farmers' access to urban markets.

In general there are no regulatory systems which enforce grades by size and quality standards in sweetpotato value chains. Sweetpotato is usually bought and sold on the basis of volume, rather

than weights. Rwanda is an exception here, where scales are found and used in urban markets and prices were quoted by weight. In most urban markets sweetpotatoes are sold in heaps. A study in Mwanza (Tanzania) described how heaps of 5-7 roots were sold at fixed prices but that in any sale additional roots, making up 10-20% of total weight would be provided as a "top up". Heaps were sorted into small, medium and large roots which sold at different prices. Medium sized roots received a relatively higher price per unit weight, and the preferred Sinia variety sold at a price premium of 14% above Polista. Cut and damaged roots were valued by traders at 93% of the price of good roots, and weevil infested roots were valued at 64% (Ndunguru *et al.*, 1998). Weevil damage may affect a majority of roots marketed in some areas when the crop is harvested in the dry season (G. Thiele, personal observation Mwaloni market, Mwanza). In Kigali, retail market varieties with different skin colour were mixed in the same heap but roots were sold by kg (G. Thiele, personal observation).

Collective action by farmers has been promoted as a means of reducing transactions costs in assembly for getting to a cost-effective volume (namely a lorry load), and of attaining bargaining power in market transactions. Thin and seasonal markets limit the potential gains to collective action, particularly when supplying local markets. In areas of commercial production for urban markets, such as exist in Uganda, either local traders organize the assembly and transport or traders based in urban markets come to the production areas, often doing the harvesting. Traders based in production areas have an advantage in organizing collective action around assembly but must rely on brokers in urban markets to break down the lorry load. Traders based in urban markets have better market intelligence and networks of retailers but are less efficient in assembly. Achieving increased efficiencies through the whole fresh root marketing chain thus appears limited to improving the efficiency of trader/broker collection practices unless there are major structural changes in urban wholesale markets allowing farmer access at lower transaction costs.

A number of different models have been tested for intervening in sweetpotato value chains:

Model 1: Proactive market creation and creation of OFSP traders group

The Towards Sustainable Nutrition Improvement (TSNI project) used a pro-active market creation model to introduce OFSP products to the market which was thin and undeveloped in Central Mozambique. It helped farmers sell to local traders, who sell to other rural consumers or local small businesses which use OFSP as a raw material (bakers, etc.). Local traders were helped to acquire OFSP booths, painted a distinctive orange color to create brand awareness, and placed in accessible locations. Quality grades were introduced and only first and second quality OFSP were

purchased, with first quality roots receiving a higher price (Low *et al.*, 2005). This type of intervention requires careful identification and training of appropriate traders and good site location, which restricts its scalability.

Model 2: Direct linkages of producer groups with urban markets

The NGO Farm Concern organized OFSP producer groups to establish partnerships which take over assembly and sell roots directly to wholesale traders, supermarkets and millers in Nairobi using the Commercial Village concept (Kaguongo 2007). Producers contracted the services of truckers for transport. They were able to capture more marketing margin and displace the assemblers on whom they had depended before.

Model 3: Developing local processing enterprises

Farm Concern helped OFSP farmers sell to a small local enterprise making SP dried chips, the miller produces flour as a service to the enterprise (fee per kg), the enterprise packages the flour, and sells to a registered market development firm that identifies outlets (Touchstone), and sub-contracts a distributor to deliver the product to large-scale supermarkets, private millers who make nutritious porridges and flours and other outlets.

Model 4: Direct linkages of producer groups with institutional markets (schools, tertiary institutions and hospitals)

The Sweetpotato Coalition project in Central Uganda linked 37 sweetpotato farmer groups with 20 local institutional markets. Farmers responded positively and sold sweetpotatoes but some were disappointed by a lack of timely payments. Rural-based pilot processing centers where used to market dried chips to millers and to process and sell sweetpotato snacks and juice in local markets (Wheatley and Loechl, 2008).

Model 5: Build trust between farmers and other market chain actors and stimulate innovation and product development to add more value

CIP and PRAPACE applied the Participatory Market Chain Approach (PMCA) with the sweetpotato value chain in Uganda (Bernet *et al.*, 2006). The PMCA is a short shock treatment which improves market chain coordination. It gets market chain actors talking to each, builds trust and sets in motion the development of market oriented innovations. The PMCA engaged farmers, market traders, representatives of marketing bodies, processors and exporters. It led to the exploration of four innovations:

Development of an orange-fleshed sweetpotato crisp product.
Construction of the kiosk for marketing sweetpotato products in the Kalerwe market.
Development of two brands of porridge mix employing sweetpotato flour as a main ingredient.
Establishment of a 'Sweetpotato Marketing Chain Club' to continue to promote innovations after completion of the PMCA exercise.

The sweetpotato crisp product was developed and is being marketed by TomCris Enterprises. The Njukunju Group is now developing another competing product. The kiosk was constructed and used for the first time at the Final Event for Phase 3 of the PMCA. The two brands of porridge developed by the SOSSPA and Kasawo enterprises have been tested in focus groups. Attractive packaging has been developed for these two products. The sweetpotato club has been established but has not yet begun to function as a stakeholder platform.

Different value chain models may be appropriate under different circumstances and elements of the models described here could be combined. In part the choice will depend on the objective, particularly the search for improved efficiencies in existing market chains, the introduction of OFSP with its associated branding, or the development of value chains for processed products. Because current markets are relatively thin, careful value chain facilitation to ensure that supply and demand grow together will be needed. If either gets seriously misaligned there will be frustration on the part of farmers who are left with produce they cannot sell or on the part of retailers who cannot meet demand from customers. However, as markets get established and the value chain consolidates, issues shift to maintenance of quality standards within the marketing chain and the introduction of new varieties, seed systems and integrated crop management techniques. A dynamic should build for the continual search for improved efficiencies, productivity, or quality within the value chain.

All these models report positive short term outcomes but there has been no serious analysis of longer term outcomes or of their relative merits. Preliminary analysis suggests that different models have different limitations. Projects which follow model 2 for example rely on collective action at farm level in assembly, in maintaining grades and standards and in contracting directly with supermarkets. This allows both a price premium and permits farmers to capture most of the market margin. However, at a project level, coordination functions and credit support in the market chain are often assumed by an NGO, instead of the supermarket or a farmer group. As promotion of OFSP deepens and demand expands, the question is whether the OFSP value chain

will become self-organizing, for example, through contracting between supermarkets and an expanding array of farmer groups and whether OFSP will increase in wholesale markets.

The introduction of small-scale processing under model 3 also provides an organizational locus for farmer collective action. The viability of processing will depend on organizing root supplies during as long a supply period as possible, while at the same time competing with fresh market demands. Initially farmer groups will have to commit to continuously supplying the processing enterprise with roots in exchange for having a floor under fresh market prices. Farmer collective action will be essential to ensure quality parameters and timely delivery in the establishment of markets for fresh roots and processing products.

Pilot experiences indicate that factors critical to the development of value chains include:

1) Ability to establish a constant supply of sweetpotato roots through piecemeal harvesting, varietal selection (different maturation periods), exploitation of different agro-ecological zones, storage capability, trader and farmer group coordination.
2) Surplus production exists at the household level.
3) Fresh root price on the market competitive with other staples.
4) For products substituting wheat flour, fresh root price versus wheat flour price.
5) Assembly and transportation costs not prohibitive between production and processing centers.
6) Economically viable products acceptable to consumers can be identified.
7) Purchasing power of target consumer groups within range of proposed product.
8) Sufficiently prompt payments can be made to farmers for their roots.

Areas for future work:

1) Systematically gather information about prices and analyze how farmers and other value chain actors access price information.
2) Test alternative models for facilitated value chain development drawing on prior project experiences.
3) Promote and analyze different options for studying collective action among farmers to improve reliability and quality of supply of roots.
4) Explore options for stimulating innovation in the value chain using a lower cost version of PMCA in the context of particular market opportunities.
5) Test different schemes for managing supply and vertical integration including potential for contract farming (drawing on experiences with cassava).

6) Develop and test different schemes for demand creation which engage all actors in value chain.

Challenge 4.5. Potential of sweetpotato as an animal feed

Current knowledge

Sweetpotato at present plays a limited role in livestock production in SSA. However, on farm research in SSA has demonstrated that sweetpotato forage varieties which produce abundant vines can be used as a high value feed for dairy cow, dairy goat, and large scale pig production, and dual-purpose feed varieties can be used as smallholder pig feed. In Asia, forage and dual-purpose sweetpotato varieties for pig production have been adopted by many farmers increasing feed availability and decreasing feed cost, although here sweetpotatoes are predominantly an animal feed and do not compete with food uses. Technologies developed for silage of sweetpotato vines and roots in Asia have further improved the nutritional value of vines and roots, increased growth rate, and decreased production cost (Peters 2008). Feeding strategy simulation models (LIFE-SIM) have been developed for pigs, dairy cows and goats to analyze their bioeconomic response to feeding strategies in different production systems (León-Velarde *et al.*, 2006; León-Velarde *et al.*, 2007).

The clearest opportunity for sweetpotato as an animal feed in SSA exists in East Africa and the Central African Highlands:
Smallholder dairy cow systems have grown significantly in most parts of the region, particularly in the highland areas.
Dairy goat production, after years of research, has increased dramatically in Kenya.
Smallholder pig production is beginning to intensify, where there is either contracting or good access to markets.

The opportunity is based on the partial replacement of voluminous Napier grass used as feed mainly for dairy cows and goats, but also pigs, with a more productive and nutritional substitute. It takes 0.6-0.7 hectares (ha) to support one cow each year, based on average Napier grass production of 35 ton/ha. CIP-SSA sweetpotato breeders estimate that, in East Africa, advanced forage varieties should easily yield 35 ton/ha of vines per season (i.e., 70 ton/ha/year where two crops are possible), and up to 60 ton/ha per season (120 ton/ha/yr) under more favorable conditions and management. This replacement would be highly profitable for dairy cow and goat producers and for the larger contracting pig farmers who combine commercial feed and vines because of cost reduction and land saving.

The advanced dual-purpose varieties, with high biomass yield from both roots and vines, selected specifically for feed production, have the potential to contribute to the growth and economic efficiency of smallholder pig production, which relies on sweetpotato roots and vines as the main bulk of pig feed. The extent of its impact will depend on the increase in total biomass of the improved varieties compared to the current varieties that are fed to pigs.

Comparing the relative merits of dairy cow, dairy goat, and pig production, we see that pure and cross-breed cows provide the most steady daily income as they are milked for 9–12 months, but require a massive amount of feed and a great deal of skilled care. Pure breed goats, due to the high prices of goat milk, yield very high income for the small amount of feed needed daily. As with most pure exotic breeds, pure breed goats also require care, investment, and skills to keep them alive and productive. Smallholder local pig production, fed on sweetpotato roots and vines-based diet, can yield comparable profits to pure breed dairy cows and goats. The forage sweetpotato could be adopted by dairy cow, dairy goat, and larger contracting pig farmers; while the dual-purpose varieties would contribute to the smallholder pig production. The potential would be greatest in areas where sweetpotato grows for most months of the year and there is a large concentration of cows, goats, and pigs, namely those East and Central African highlands with access to urban markets (Peters, 2008).

The use of sweetpotato in commercial feed ration depends on global maize price trends. The potential of substituting maize with sweetpotato in commercial production will be determined only when the long term price differential becomes clear between maize, on the one hand, and sweetpotato, cassava, and soybean meal, on the other.

Areas for future work:

1) Evaluate yields of forage and dual purpose sweetpotato varieties in multiple locations.
2) Carry out post harvest trials on cutting, silage, and feeding in order to enhance the role of sweetpotato in various livestock feeding systems. Cutting allows vines to be mixed with other feeds in order to balance the feed, and reduces feed waste. Cutting is needed for silage. Silage can be made with various additives (e.g. chicken manure), and the appropriate additive depends on the availability and cost.
3) Feeding trials are needed to determine the replacement rate of sweetpotato vines for Napier grass for dairy production, looking at returns to labor as well as returns to land.
4) Trials of sweetpotato silage are needed to estimate economic and growth efficiency of silage use.

5) Use minimum data trade off analysis to understand effects on profitability of different feed based enterprises across the whole farm.
6) Carry out collaborative trials with factories on commercial feeds including sweetpotato either on station or with contracting farmers.
7) Analyze long term shifts in prices of raw materials for commercial feed and carry out economic analyses of different feed compositions using linear programming and LIFE-SIM simulation models to understand under what relative prices sweetpotato would be competitive with maize and cassava.

CONCLUSION

Despite its bulky nature and undifferentiated use there are real prospects for improving sweetpotato's value chain. Facilitated market development will be needed to increase the efficiency of existing chains and develop new chains with careful balancing of the growth of supply and demand creation. Much of this work is linked to OFSP. Its unique set of market attributes creates new hope of breaking the perception of sweetpotato as a poor man's food and increasing processing and marketing of sweetpotato. This should generate a series of potentially favorable impacts on the livelihoods of the poor who produce and consume the crop.

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