

# Setting Post-harvest Strategies for Food Security and Income Generation in Soroti, Uganda

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## *Abstract*

Sweetpotato has become the most important crop in Uganda in recent years following the devastation of cassava harvests by viral epidemics. Throughout the country the primary function of sweetpotato is food security, but that does not diminish its potential for generating income through appropriate post-harvest utilization. This paper examines related aspects of sweetpotato production, processing, utilization, and marketing to set post-harvest research strategies for addressing local food security and income generation. The findings indicate the following strategy setting. First of all, to ensure a steady supply of this important staple, research efforts need to focus on planting material, appropriate technology for processing, and storage of fresh or processed roots. Secondly, improvement of the current sweetpotato-pig system exhibits great potential for generating higher rural incomes through increased pig growth. Thus, detailed recommendations for pig-feed trials, based on local conditions, are proposed to improve the existing system. Finally, the potential for sweetpotato flour processing is also explored for added value. The findings indicate that traditional low-quality sweetpotato flour has commercial potential only if cassava fails to reestablish. In addition, high-quality flour may be produced to substitute for wheat flour, if technical considerations are addressed to improve its quality.

**Key words:** sweetpotato, postharvest, food security, sweetpotato-pig system, sweetpotato flour processing, composite flour, income generation, value-added

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## Introduction

Uganda is the largest sweetpotato producer in Africa and sweetpotato plays an important role in providing food security to many areas of Uganda where it is cultivated (Bashaasha et al.1995). This role has become more prominent in areas where cassava, the second most important crop next to banana, has been destroyed by serious epidemics of African Cassava Mosaic Disease (ACMD) which have caused severe food shortages and hardship in Uganda in recent years (Otim-Nape et al. 1995). Bashaasha et al. (1995) identified sweetpotato post-harvest constraints such as lack of markets, poor storage facilities, and limited use opportunities, among other agronomic constraints to production, as some of the major obstacles to sweetpotato development. These constraints indicate the need to examine sweetpotato post-harvest strategies to overcome the obstacles and address the issue of food security in Uganda.

In addition to examining ways to overcome constraints to food security, sweetpotato post-harvest potentials also need to be explored as opportunities for income-generation. The major post-harvest potentials identified in other sweetpotato-producing areas in the world include sweetpotato as animal feed as well as sweetpotato starch and flour processing. For example, Scott (1991) estimates that 65 percent of total sweet potato output in China goes to animal feed, principally to pigs. Wang (1998) reported a figure of 35 percent in Shandong Province, and Peters' (ms. submitted) found nearly 80 percent animal feed usage in Yilong County of Sichuan Province in China. Sweetpotato is an ideal livestock feed because the roots provide a source of energy while the leaves constitute a source of protein, and both can be used in fresh and dried form or fermented into silage (Woolfe 1992). In addition to China, sweetpotato production is also substantially linked to pig production in Vietnam (Bottema 1992). An on-farm pig-feed trial conducted in Vietnam indicated that better management of this sweetpotato-pig feed system may improve pig growth and increase economic efficiency (Peters 1998).

In addition, sweetpotato in China has also been processed into starch, mostly at the household enterprise level, to generate rural household income (Marter and Timmins 1992). Most starch is further processed into noodles for added value (Tang et al. 1990), and this agro-processing opportunity is on the rise. In Sichuan Province, five percent of all sweetpotato was processed into starch/noodles in the 1970s, ten percent in the following decade, and 20 percent in the 1990s (Li et al. 1992). In Shandong Province, 48 percent of all sweetpotato was processed into starch by industries in 1998 (Wang 1998). An alternative-use analysis for China showed that well-managed sweetpotato-pig rearing and starch/noodle processing have the potential to generate greater income than the current pig-raising systems or sales of fresh sweetpotato in the market (Peters, ms submitted).

This phenomenon in China coincides with a similar trend in Indonesia where per capita consumption of fresh roots declined as incomes increased (Gunawan 1996). A study in East Java found sweetpotato flour processing to be a potentially feasible enterprise, if certain technical issues were resolved (Peters and Wheatley 1997). Subsequent technical trials indicated that marketability and profitability of the flour can be achieved to make sweetpotato flour processing

feasible (Peters and Wheatley, ms submitted). Feasible sweetpotato-flour processing signifies income generation opportunities for rural households.

Within the Ugandan context, sweetpotato flour production and improved sweetpotato-pig rearing are two immediate potential avenues for enhanced income generation. Low-quality sweetpotato flour is usually milled from dried chunks and made into composite flour with cassava and/or sorghum flour, as a means of storing sweetpotato. The farmers, however, have never marketed the flour, marketing instead only the dried chunks at a considerably lower value. Imported wheat flour commands a high price in Uganda (900 ush/kg, equivalent to US\$ .82<sup>1</sup>) and composite sweetpotato/wheat flour could reduce the price of flour. In Indonesia, where subsidized wheat flour only costs approximately US\$.30 per kilo (depending on the currently fluctuating exchange rates), high-quality sweetpotato flour is already a potentially profitable product (Peters 1997a). This suggests good economic potential for Uganda's sweetpotato flour production.

Moreover, just as cassava gave way to sweetpotato, pigs emerged as an important livestock after cattle were confiscated or raided during a military insurgency and attacks by the neighboring Karamajon tribe between 1987 and 1992. The unconfined pigs are mainly fed on sweetpotato roots and vines, as they are in China and Vietnam. Therefore it seems reasonable to investigate the possibility of similarly modifying and improving the current sweetpotato-pig system to increase profit/income.

Based in Soroti District, a major sweetpotato producing area in northeastern Uganda, the goal of this research was to examine the area's socio-economic, agronomic, and marketing characteristics in order to identify appropriate sweetpotato post-harvest utilization strategies for food security and income generation. The specific objectives of this research were as follows:

1. To identify the most important post-harvest research activities to address the issue of food security.
2. To determine the possibility of and methods to improve the sweetpotato-pig feed system.
3. To examine the constraints and opportunities for sweetpotato flour processing (i.e., the conditions under which flour processing is economically feasible).
4. To recommend priorities and strategies for post-harvest activities in this area.

## **Methods**

This research was conducted during three and a half weeks of intensive fieldwork in November and December 1997 in three villages in Soroti District—Dokolo, Aukot, and Awoja. The fieldwork was preceded by a one-week field trip to Western Kenya and Uganda to study sweetpotato production and utilization. One group interview in each village and fifty-seven individual interviews on homesteads were administered during this period. The researcher was accompanied during all the interviews by an extension worker from the Soroti District Agricultural Office and the head of the Farmers' Association of each village. The extension worker, a native of Soroti who was well acquainted with almost all of the respondents, served as a translator,

while the head of the Farmers' Association selected the respondents and informed the homesteads of our legitimate intentions for the interview. In addition to farmer interviews, a less comprehensive market study was conducted to understand the flour and pig demands locally and nationally.

The homestead questionnaire was designed to collect data on: 1) sweetpotato production, consumption, and marketing, and 2) pig production and feeding habits. While most responses were based on farmers' recollections, daily human and pig consumption of sweetpotato was directly measured (i.e., for each homestead, a man and a woman were asked to pick out the sweetpotatoes s/he eats daily and the amount fed to one pig daily for weighing.) Soroti flour wholesalers and retailers were interviewed to inquire about the price, sales volume, and potential for sweetpotato flour. During a visit to the livestock market, a district veterinarian, who is in charge of keeping records on animal sales transactions in the market, was interviewed concerning changes in the pig market over time.

## **Food Security**

### **Sweetpotato Production and Processing**

Almost all homesteads in the three villages rotated their fields and left at least a few acres fallow at all time. Some rented more fertile land to cultivate even when they had land lying fallow, because of the low land-rental cost. On average each homestead cultivated three to four acres of cassava, sweetpotato, sorghum, peanut, millet, and cowpea.

Most homesteads in Dokolo increased sweetpotato planting areas in 1997 (average 1.1 acres in 1996 vs. 1.37 in 1997), while most decreased the planting areas in Aukot (1.7 to 1.22 acres) and Awoja (2.1 to 1.43 acres) (Table 1). The decision affecting the planting area was influenced mainly by: 1) planting material availability, 2) rain conditions, and 3) labor availability. Fresh market prices from the previous year did not affect the decision on planting area because, for most cultivators, sweetpotato was an important food security crop, especially since the demise of cassava. Even those who planted certain areas specifically as a cash crop were not deterred by the low prices of the previous year; due to the frequent fluctuations of the market, prices could always go up.

When moderate rains are available throughout the sweetpotato season, the estimated yields were 4.8 tons per hectare in Dokolo, 5.8 in Aukot, and 8.4 in Awoja (Table 1). One area in Awoja was situated close to swamps where large herds of cattle had been held in order to keep them from grazing on crops before the insurgency when almost all cattle were lost. The manure made these lands quite fertile and one farmer claimed that he had harvested 90 bags<sup>2</sup> of sweetpotato on one acre<sup>3</sup> ( $\approx 27$  tons/ha.). This contributed to high yields and a greater number of farmers engaging in sweetpotato cultivation as a cash crop in Awoja. Every three to four years, there would be one year of insufficient rains and during these years productivity was reduced to two to three tons/ha.

On a normal year<sup>4</sup>, sweetpotato mounds are heaped<sup>5</sup> during March to July, but most frequently in April and May. Those who cultivated for cash tried to have the sweetpotato planted by the first of rains in March to make full use of the rains and to harvest early before prices fell as harvests progressed (Figure 1). These farmers tended to hire more labor to ensure timely heaping and planting. Others, however, constrained by lack of planting material from volunteer plants, were not able to heap as early. Thus, preparing for planting material was a way to ensure an early crop and higher yields, as well as to secure better market prices. However, on-station experiments over two seasons at Serere, a government research station near Soroti, showed that the months of June and July were the most favourable planting months for high yields and low weevil damage (Smit, pers. comm.).

As a food security crop, between July and November fresh roots were consumed from piecemeal harvests since they did not store well. Once the dry season began, the roots risked the chance of weevil attack in the ground and had to be harvested. From November to January sweetpotato was harvested in mass quantity, subsequently peeled and processed into *inginyo* and *amukeke* for storage. *Inginyo* are crushed chunks, which were sun-dried and later consumed as *atap*, a composite flour made from sweetpotato, cassava, and/or sorghum. *Amukeke*, on the other hand, are sliced and sun-dried, and often boiled for breakfast.

The processing procedure begins with labor-intensive peeling, done mostly by women. It takes approximately 24-29 mandays to peel one acre of mass harvest (Table 2a). Peeling did not simply remove dirt and clean the roots, which could be better accomplished by washing. The respondents revealed that peeling served the important functions of: 1) removing weevil-infected parts which gave a bad taste to both *inginyo* and *amukeke* and also made them undesirable to pigs; 2) facilitating faster drying since peels took longer to dry; and 3) making *inginyo*, *amukeke*, and *atap* more palatable. Of the three functions, removing weevil damage was of the greatest importance, which for the farmers justified the heavy labor inputs and costs of hired labor.

Once peeled, approximately 70 percent of the roots were crushed into *inginyo* while 30 percent were sliced into *amukeke*. Slicing took skill and was often contracted out to an older man (Table 2b). It was a slow process since a large and cumbersome knife was used. Crushing, on the other hand, done only by women, was a faster process requiring little skill (Table 2c). Though a faster process, crushing required more labor time than slicing due to the considerably greater volume involved; therefore, hired labor for crushing was still necessary. Even though slices could be milled into flour to make *atap* like the crushed chunks, the chunks also served other important functions that could not be replaced by slices. First of all, chunks were more resistant to storage insect pests and could last four to five months while slices might last only three to four months<sup>6</sup>. Secondly, chunks packed better than slices and required less storage space. Thirdly, *inginyo* was more marketable and profitable than *amukeke*, even though both were less profitable than fresh roots<sup>7</sup>. Moreover, when in dire need of cash it was also easier to sell *inginyo* than *amukeke*. Finally, chunks required less labor to process than slices.

Once *inginyo* and *amukeke* become seriously damaged by storage insects in April through June, they can be made into a local brew called *waragi* (made from either sweetpotato or cassava), to save them from being wasted. It took about 60 kg of *inginyo* to make 20 liters of *waragi*, yielding 20,000 ush of profit. Assuming a 25 percent fresh root to *inginyo* conversion

rate, this value yielded 83 ush per kg of fresh roots, or an equivalent of 10,000 ush per bag. This is a very good value considering that most fresh roots were sold for 5,000 ush per bag in 1996.

## **Post-harvest Research Priorities**

Weevil attack precludes storing sweetpotato in the ground, but once harvested and processed, storage insect pests again limit post-harvest storage to four to five months at most. At the current stage of storage technology, sweetpotato, in fresh or processed form, is available for home consumption for up to only nine months a year. This could threaten food security, especially in the absence of cassava. Thus, improved sweetpotato storage for fresh roots and processed chunks and slices must be the first priority for post-harvest activities to address the food security issue. The International Potato Center has tested the effect of salting chips and proper storage of chips in sacks on insect control and the results were longer storage life, up to six months for *amukeke* (Smit, pers. comm.). This technology, however, needs to be tested and disseminated in more areas.

Secondly, peeling, slicing, and crushing manually are all labor-intensive and costly activities that deserve technical assistance. Peeling cannot be replaced by washing; therefore, developing technology for weevil-damage removal would greatly help reduce female labor. Furthermore, developing a slicing machine would relieve labor requirements for making *amukeke*, but this would not solve the labor problem for crushing. Considering that crushing is strictly women's responsibility, a crushing machine would greatly reduce women's heavy work burden.

Furthermore, assisting farmers in preparing for planting material instead of waiting for voluntary vines, would have implications beyond production. As stated earlier, early planting leads to early harvest when farmers can secure higher prices. Lastly, *waragi* brewing turns the storage constraint into an income-generating opportunity, but the brewing process is long and labor-demanding. Technology invented for any part of the long brewing process may help increase the efficiency.

## **Improvement of the Sweetpotato-pig System**

### **Current Practice and Status**

Thirty-nine of the 57 homesteads interviewed raised pigs. The head of the Farmers' Association of each village estimated that 40 percent of homesteads in Dokolo, 70 percent in Aukot, and 80 percent in Awoja raise pigs (Table 3). The percentage was much higher before the alleged African Swine Fever devastated the pig population in this area in 1995-96. Pigs and sweetpotato were perceived as ways to gain quick turnaround of cash while cattle and cassava were for the long haul. Tethered only loosely to a tree or a stump in the shade, the pigs grazed around the area most of the day and were fed twice a day in general.

Most homesteads raised only one pig and the average number of pigs per homestead in the three villages were 1.69, 2.13, and 1.67 (Table 3). Most farmers considered pig-raising a profitable venture, but hesitated to raise more for the following four common reasons: 1) insufficient feed during the dry season, 2) difficulty in confining the pigs, 3) fear of African Swine Fever, and 4) lack of cash to buy piglets. The homesteads that did not raise pigs stated similar reasons for not raising pigs. Managing and confining the pigs was of great concern because a steep fine was imposed if the pigs were caught grazing on neighbor's crops.

Even though the farmers considered pig-raising profitable, pig growth was grossly under achieved with an average monthly growth rate of 3.45 kg in Dokolo, 2.11 kg in Aukot, and 2.7 kg in Awoja (Table 3). In general, after seven to eight months of rearing, the pigs reach only 20-30 kg, a weight range commonly associated with piglets elsewhere in the world. The pigs were mainly fed on sweetpotato roots and vines, along with other locally available feeds—brew residues, fish bones, grass, mango, and papaya—which had little cash value (Table 4). At this rate of growth, the average value of sweetpotato<sup>8</sup> was as low as 24.4 ush kg<sup>-1</sup> in Aukot, up to 32.7 in Dokolo (due to the low prices of the piglets), and as high as 38.7 in Awoja (Table 5). These values were lower than the fresh market prices, which made pig-raising not particularly profitable at these growth rates.

The following management (or lack there of) and feeding practices observed, among other factors, contributed to slow growth rate. These observations are significant in that “the major limiting factor in growth rate under most primitive conditions is a lack of protein in the diet and failure to control internal parasites (worms) and environmental stress” (Goodman 1994:75).

- Pigs rooted around the trees on which they were tethered and often were infested with worms. Most homesteads in Awoja treated their pigs for worms (Table 3) while few did so in Aukot; consequently, despite feeding the lowest amount of sweetpotato, Awoja achieved the highest growth rate.
- Pigs were often tethered next to open latrines and the exposure to human feces put pigs at risk for infection (Holland et al. 1995).
- The local breed may not be a fast growing race of pigs. This, however, needs to be tested in a trial because others have found it not to constitute a constraint<sup>9</sup>.
- The daily diet was not balanced and feeding was sporadic.
- Sweetpotato roots were mostly fed fresh (Table 4) and even when cooked, the roots were cooked too briefly to allow starch to break down.
- The pigs lacked any protein supplement, especially in light of the fact that sweetpotato vines, the main source of protein, were fed only during the harvest season. Only one homestead claimed to dry and conserve the vines for the dry season.
- The vines were not chopped or cooked and whole vines were given to pigs, which ate only the leaves and left the vines untouched.

## **Pig Market and Demand**

None of the respondents cited “lack of market” as a constraint to pig raising. Pigs in this area were marketed in three ways. Firstly, the farmer slaughtered the pig himself and took the meat to the village market to sell by weight. Pork sold by the kilogram commanded a higher unit price than a live pig, but there was more work involved. Secondly, if the farmer was not interested in engaging in the work of slaughtering and selling, he sold the live pig to a butcher who would offer a set price for the pig. The value was lower, but it relieved the farmer from the work. Thirdly, in addition to the local market, livestock was sold in a district market which rotates around various districts in this area each day, and one such market is available daily.

In addition to the local and district markets, Soroti used to have access to the Kampala market. The district veterinarian, who was in charge of the Otuboi livestock market on Saturdays, revealed that before the insurgency, Kampala trucks used to come to the Otuboi market each Saturday to collect pigs. The local middlemen would collect the pigs prior to the arrival of the city collectors with the trucks. Live pigs collected for the Kampala market commanded twice the price of the local market. The pig production in this area was much higher then when the Kampala market was available. At that time the youths in particular were keen on raising pigs because of the quick profit pigs provided. Production and sales usually peaked twice a year around Easter and Christmas.

This system broke down during the insurgency, pig production fell, and the Kampala market was lost all together. The local district office now encourages farmers to raise the pig stock again so that they may regain a share of the Kampala market. In fact, Kampala pig marketing researchers still come to this area from time to time to check on the supply levels. The problem in the pig industry is not demand but rather supply, and if this area can supply enough for truckloads, the veterinarian felt certain that the trucks from Kampala would soon return. Until that happens, pigs are sold in these district markets in relatively small quantities. For example, the Otuboi marketers slaughtered 15 pigs and sold 10 pigs and 15 piglets each Saturday, a total quantity of 450 kg per week. Assuming similar quantities were sold in other markets each day of the week, there is a local demand of 225 pigs a week in the Soroti district.

### **Post-harvest Activity: Proposed Integrated Trial**

The combination of sub-optimal pig growth and the potential Kampala market presents a research opportunity to modify and improve the current sweetpotato-pig practices. In light of the absence of utilization of pig manure, which could be a valuable fertilizer to increase the low sweetpotato yields, an integrated research combining pig trials and production trials is recommended. In the pig trial the pigs should be confined, as one of the ways of improving growth, and the manure should be collected and applied as fertilizer in a production trial designed to increase yields. This integrated system is practiced faithfully by farmers in China and Vietnam to maintain soil fertility and increase crop productivity.

### **On-farm Pig Trial**

A local commercial pig raiser and veterinarian's assistant in Soroti, who had expressed a keen interest in pig raising, had previously conducted a trial on his modest pig farm (Okoth and Epechu 1997). Okoth and Epechu (1997) identified maize bran, sunflower cake (sunflower oil residue), and small fish as locally available feed supplements at affordable prices. Since publication of the report, Epechu (pers. com.) has further encountered the availability of cow's blood from one local slaughterhouse, which slaughters 10 cattle each day, as a free feed. He collected 40 liters of blood a day and processed it by boiling and drying. This dried blood was then mixed with maize bran and other feed, and he then noticed its positive effect on pig growth. Other smaller slaughterhouses in the district also have free blood available for feed. A local NGO also added some commercial additives to the local feed in the past, but a search for these additives in Soroti indicated that it was no longer available.

In addition to feeding management, Epechu (pers. com.) believed that the exotic *large white* breed was superior to the local breed and that *large white* pigs achieved higher growth rates when fed the same diet. Another local NGO, on the other hand, observed no difference in growth between local and exotic breeds on their pig farm. Since *large white* piglets are more expensive and may not adapt to the local environment, it is important to verify the advantage of the breed in the proposed trial.

These findings, along with the data collected from farmer interviews, suggest that four hypotheses, tested under four corresponding treatments, should be tried in an on-farm trial. These four treatments should be constructed on the general baseline diet of sweetpotato roots (fresh and dried), vines (fresh and dried), and weevil-free peels, as well as mango and *adakai* (alcohol-brewing residue), which is available most of the time while *waragi* residue is only available during April to June. Blood is apparently a good supplement due to its high protein content, but it may not always be available if the demand increases drastically should farmers begin using it as pig feed. An alternative, reliable and affordable supplement needs to be examined; thus, another treatment with sunflower cake should be included, because its protein content is much higher than that of maize bran (Table 6). Cottonseed oil residue and soy residue should not be ruled out completely as potential protein supplements because they used to be common crops in this area and may reappear in the future.

**Hypotheses:**

- H<sub>1</sub>: Balanced diet and good management improves pig growth
- H<sub>2</sub>: Use of improved breeds improves growth
- H<sub>3</sub>: Balanced diet enhanced with sunflower cake as supplement improves growth
- H<sub>4</sub>: Balanced diet enhanced with blood as protein supplement improves growth

**Treatments:**

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Treatment 1	Treatment 2	Treatment 3	Treatment 4
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Management	Confined; disease control with shots, medication, a clean environment, and cooked feed.	Confined; disease control with shots, medication, a clean environment, and cooked feed.	Confined; disease control with shots, medication, a clean environment, and cooked feed.	Confined; disease control with shots, medication, a clean environment, and cooked feed.
Diet	Formulated balanced daily ration Local breed	Formulated balanced daily ration <i>Large White</i>	Formulated balanced ration + sunflower cake <i>Large White</i>	Formulated balanced daily ration + blood <i>Large White</i>
Breed	Traditional practice observed everywhere	Treatment 1	Treatment 2 Treatment 4	Treatment 2 Treatment 3
Control				

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During the dry season when sweetpotato vines are scarce in Vietnam, the price of vines can reach four times that of sweetpotato roots (Peters 1997b). The Soroti homesteads, on the other hand, fed the vines to pigs during the harvest season and discarded the rest in the field once the harvest was over. Those who did not raise pigs discarded all the vines in the field. These discarded vines account for considerable protein and fiber loss, and subsequent slow growth. Efforts should be made to assist local farmers to conserve vines (i.e., drying the vines during the harvest season) for use during the dry season. In mountainous regions in Vietnam where no protein supplement is available, finishing pigs consume more than 7 kg of vines daily as the only source of protein (Peters 1997a).

Pigsties should be constructed with locally available material and attention must be paid to design which would allow air circulation and light in the pens, and be large enough to allow pigs to move about, as well as facilitate manure collection<sup>10</sup>.

Pigs should be raised in two seasons, and the trial should coincide with one of these two seasons (Table 7). The first season begins in November when sweetpotato processing begins and dried chunks are available for the following five to six months. The pigs will be slaughtered by Easter so that the people can avoid having to feed the pigs during the May-June period when food is scarce. One drawback of this season is that it coincides with the very hot season during which pigs may lose their appetite. Another season begins in July when the piecemeal harvest begins and fresh roots are abundant. These pigs are fed on a combination of fresh roots and dried chunks as the season progresses. After five to six months, these pigs are ready for the Christmas slaughter.

The importance of disease management cannot be overstated. It was assumed by all respondents that the disease that killed many of the pigs during 1995-96 was African Swine Fever (ASF), which is a virus for which no effective vaccine is currently available. However, it is not safe to assume that ASF was the culprit without scientific investigation, since “*African Swine Fever*, apart from its greater severity, is almost impossible to differentiate from hog cholera without serological test” (Callis et al. 1982:13). In light of the fact that there are preventative

measures for cholera, but none for ASF, it is of great importance to determine the true nature of the illness so that treatment may be targeted accordingly. Another disease that must be controlled is *cysticercosis* since swine tapeworm is a major problem in this area. Among other factors, exposure to human feces puts pigs at risk for infection (Holland et al. 1995). The proposed best management practices—confinement, de-worming, and cooked feed—would all contribute to breaking the cycle between humans and pigs.

## **Sweetpotato Flour Production**

### **Sweetpotato Root Production Cost: Cost of Raw Material for Flour Production**

Until cassava reestablishes itself, the most important role of sweetpotato will continue to be food security. While cassava is in short supply, sweetpotato is consumed twice a day and the current production cannot even satisfy nine months of home consumption, let alone the demand for pig feed, in Dokolo and Aukot (Table 8). The implication is that current sweetpotato production leaves no extra supply for commercial processing, such as flour production. This means that, for flour production, extra sweetpotato must be planted specifically for such a purpose. Currently, 67 percent of the homesteads in Dokolo, 44 percent of those in Aukot, and 71 percent of those in Awoja claimed that they have no extra family labor for all production activities—heaping, planting, weeding, and harvesting (Table 9). In the case of planting extra sweetpotato for commercial purposes (whether sold as fresh roots or processed as flour), all labor must be hired, adding extra costs to production. The price of sweetpotato flour must be high enough to absorb the additional costs. On average, Aukot farmers were not interested in commercial production if the price was below 16,000 ush/bag (133 ush kg<sup>-1</sup>); likewise, Dokolo and Awoja farmers would only do so for more than 14,000 (116 ush kg<sup>-1</sup>) or 9,700 (80 ush kg<sup>-1</sup>) respectively (Table 9). Sweetpotato in Awoja has a higher average yield of 7.35 ton/ha (Table 1), thus farmers in that village can accept a lower price than the others. Aukot farmers, on the other hand, put a high value on their time and labor<sup>11</sup> and were adamant that the price must reflect this value.

Labor requirements and costs for heaping, planting, weeding, and harvesting one acre of the home consumption crop are summarized in Tables 10a-d. Based on labor requirements which include some family labor and some hired labor for all activities, plus the cost of renting land and oxen, the total cost for one acre of production ranges from 31,722 ush in Dokolo to 43,987 ush in Aukot (Table 11). The cost of producing one kilo of sweetpotato varies with the yield. During a year with sufficient rain, it would cost 17 ush kg<sup>-1</sup> in Dokolo, 21 in Aukot, and 12 in Awoja. If all aspects of production were performed by hired labor, the total production cost (including land and oxen rentals) would rise and the cost of producing one kilogram would increase to 27 ush kg<sup>-1</sup> in Awoja, 41 in Aukot, and 49 in Dokolo (Table 11). On the other hand, if the farmers engaged family labor for planting and weeding, it would cut down the production cost and the per-kilo cost would be reduced to 21, 32, and 36 ush kg<sup>-1</sup>, respectively.

Table 12 shows the analysis of the minimum raw material (fresh root) price for flour in order: 1) for farmers to be willing to produce sweetpotato for commercial purposes, and 2) to compete with fresh root market profits. If hired labor is employed for all aspects of production, the production cost for one kilogram of fresh root is shown in column (a). Assuming a 25 percent fresh root to flour conversion rate, the raw material price for one kilogram of flour is shown in column (b). The minimum root price that is considered profitable, for which farmers are willing to provide a steady supply, is shown in column (c). The net profit from farmers' requested fresh root price and production cost with total hired labor is shown in column (d). To match this profit, the price of raw material for flour must be the combination of production cost and farmers' potential profit from selling fresh root at their requested price. The minimum raw material cost, covering only the production cost and alternative profit before taking into consideration the processing cost, is shown in column (e).

### **Linking Raw Material with Processing: Cost of Flour Production**

Sweetpotato flour processing in Soroti would involve peeling, shredding (or slicing, or crushing), drying, and milling. Based on all hired manual labor for peeling and crushing, it would cost 30 ush (Dokolo), 22 ush (Aukot), and 11 ush (Awoja) to process one kilogram of flour (Table 13). Adding the cost of the raw material with the processing cost and milling cost, the minimum price of flour would have to be 323 ush (Dokolo), 288 ush (Aukot), and 182 ush (Awoja) in order for it to be profitable for the farmers. The reasons that the price for Awoja is considerably lower than that in the other two villages are: 1) high yield, 2) low labor costs, and 3) satisfaction with a lower price (which is related to high yield). In Awoja, particularly among the homesteads close to the swamp area where yields are high, farmers seem more commercially oriented and sell more sweetpotato (Table 15). However, this could be attributed to a biased sample—almost all homesteads interviewed in Aukot and Dokolo raised pigs while only 67 percent of Awoja sampled homesteads were pig-raisers. There could be a categorical difference in farming orientation between pig-raisers and crop-growers.

In addition to the economic considerations, the following are two environmental concerns regarding sweetpotato flour processing in this area.

- Lack of water. Most homesteads in all three villages must travel one to two km to fetch water. Water is not a major constraint for producing low quality flour, but would be a constraint for high quality flour production.
- Lack of adequate drying facilities. Crushed chunks or slices are dried on rocks if the homestead is fortunate enough to have access to some. Otherwise, they are dried on the ground covered with cow dung. Even though the rocks provide a cleaner surface for drying, the chunks or slices still risk the chance of collecting dust and sand on them. Drying racks, which lift the slices or chunks off the ground, would need to be installed to produce cleaner flour for the market.

## Linking Flour Production with Marketing

Sweetpotato flour could be marketed as *atap*, a low-quality flour consumed by the general population as a staple. Low-quality flour of cassava, sorghum, and maize are commonly traded in large volumes for making *atap* and the prices of these three types of flours are 4-500 ush kg<sup>-1</sup>. Usually the traders purchase dried grain or roots and have them milled; thus in Soroti, there are no wholesale buyers for pre-made *atap*. Sweetpotato *atap* is only observed in the market during the dry season—December until March. In 1997, due to the changing weather patterns, there was little sweetpotato roots or *atap* in the market. However, even during a normal year, sweetpotato *atap* has a limited market. One of the five traders who carried sweetpotato *atap* estimated that, during these three months, each of the five traders sold 100 kg per day, indicating a total demand of 45,000 kg of flour, or the equivalent of about 180 tons of sweetpotato roots.

The price of sweetpotato *atap*, however, is considerably lower than that of other types of *atap* and only sells for 150-200 ush kg<sup>-1</sup> during a normal year and 250 ush kg<sup>-1</sup> during periods of relative famine. Low demand is the reason for such low prices, and there are two reasons for low demand. Firstly, unlike cassava *atap* which is a traditional food and consumed all over Uganda, consumption of sweetpotato *atap* is limited to the *Teso* people, the tribe living in the Soroti area, and the *Karamojon* tribe. There is a limited market in Kampala, sold only among a small number of *Teso* people who relocated there. Secondly, in order to offset the sweetness in sweetpotato *atap*, tamarind must be added to the flour. Not everyone likes the taste of tamarind, nor is it always available.

The low price, low demand, and the fact that traders do not purchase pre-made flour suggest a dismal future for sweetpotato *atap* in the marketplace. However, there is no inherent reason that sweetpotato *atap* should command lower prices than cassava and sorghum, with lower prices due simply to lower desirability. It is hypothesized that if the problem with African Mosaic Virus on cassava persists, sweetpotato *atap* may eventually acquire higher desirability status, which would result in prices approximating those of cassava or sorghum flour. Follow-up research should monitor the production of sweetpotato and cassava to determine whether and when it becomes profitable to produce sweetpotato *atap* commercially.

The retail price of wheat flour in Uganda reaches 1,800 for a two-kg bag. It is reasonable to project that sweetpotato flour, if acceptable for wheat/sweetpotato composite flour, can command a price of at least 550 ush kg<sup>-1</sup>. At this price, it is certainly profitable to produce sweetpotato flour (Figure 2). However, two issues require further investigation before feasibility can be established. First, the requirements for sweetpotato flour quality and price must be identified. Most likely this market mainly exists in the three major cities of Uganda—Kampala, Jinja, and Mbale. Samples of high-quality sweetpotato flour must be distributed with suitable recipes to various flour users to conduct experiments in order to learn about their price and quality requirements. Secondly, if the market exists, technical issues related to producing high quality flour with the acceptable color, texture, and purity (i.e., free of sand and dust) must be addressed.

Before the feasibility of processing sweetpotato flour either for *atap* or for composite flour can be established, research efforts directed toward identifying high yielding varieties with high dry matter content could improve profitability and make flour processing at least economically feasible. Concurrently, research efforts should be oriented toward understanding the shifting pattern between sweetpotato and cassava production in order to project to what extent sweetpotato might substitute for cassava. Such understanding would help determine whether sweetpotato is faced with the opportunity of becoming a major crop for both food security and processing, or if it is simply filling in until cassava recovers its viability.

## **Conclusions: Overall Strategic Priorities**

- For food security, the post-harvest priorities lie in developing technologies for crushing, slicing, removing weevil-damage, and storing fresh root and processed *inginyo* and *amukeke*.
- Farmers are keen on raising pigs and on learning about better management of pig-raising; therefore, modified pig-raising should be a priority for income-generation activities. The modified system will put demand on highly valued labor and compete with the potential labor demand for commercial sweetpotato production for flour. In addition, flour processing does not currently appear feasible on a commercial-scale. Thus, post-harvest activities for income-generation should first focus on pig production (i.e., a pig-feed trial). The trial should be scheduled in July when piecemeal harvest begins. Concurrently, a production trial utilizing organic fertilizer (i.e., manure from the confined pigs) should be conducted on farm. The results of the trial on growth and cost effectiveness should be used to compare with the potential profits from flour production to inform the next level of research activity. In addition, dried sweetpotato vines must be incorporated into the trial to test the effect of additional volume of vines in the diet and demonstrate the use of dried vines to the farmers.
- While post-harvest efforts should focus on pig production, breeding programs for selection and introduction of high dry matter and/or yielding varieties may be undertaken concurrently to improve the profitability of potential flour production.

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- <sup>11</sup> US\$1 = 1,100 ush (Ugandan Shilling).
- <sup>2</sup> Bags are the measuring unit of sweetpotato production and sales, however, the sizes of these bags are not even. They range between 120-150 kg per bag. In this report, all calculations are based on 120 kg/bag.
- <sup>3</sup> Sweetpotato is harvested and sold in bags and each bag contains 100-120 kg of fresh roots.
- <sup>4</sup> Due to the El Nino effect, 1997 was a very abnormal year as the normal weather pattern was altered drastically.
- <sup>5</sup> After plowing, approximately 5,000 individual mounds of soil per acre are built, on which sweetpotato is planted.

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<sup>6</sup> CIP staff have been working with the farmers to improve storage and the results show six months of storage life for *inginyo*.

<sup>7</sup> The prices of fresh roots, *inginyo*, and *amuokeke* are comparable if calculated based on conversion rates only, but if labor costs are taken into consideration, *amuokeke* is least profitable due to the high labor inputs.

<sup>8</sup> Calculated by the value of pigs minus the cost of piglets, divided by the number of kilograms of sweetpotato consumed during the feeding period.

<sup>9</sup> An NGO in Soroti raised both foreign breeds and local breeds and found the growth rate to be similar, but they have since sold all the pigs, so this was not observed first hand.

<sup>10</sup> Pigsty design should conform to one of two styles: 1) sloped with an area at the low end to collect manure, or 2) built with a slatted floor to allow droppings to enter a holding tank below the floor.

<sup>11</sup> In this area, a full day's work is often from 6 to 10 -11 am. All the labor is fully engaged at this capacity of work load.