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Sweetpotato Post-harvest Strategies for Food Security and Income Generation: The Case of Soroti, Uganda

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Introduction

Uganda is the largest sweetpotato producer in Africa and in most areas of the country, it plays and important role of providing food security in areas 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 the African Mosaic virus. Bashaasha et al. (1995) identified sweetpotato post-harvest constraints such as lack of markets, poor storage facilities, limited use opportunities, among other agronomic constraints to production, as some of the major obstacles to sweetpotato development. These 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 constraints to food security, sweetpotato post-harvest potentials also need to be explored as opportunities for income-generation. These opportunities include sweetpotato as pig feed, starch, and flour. For example, accounting for approximately eighty per cent of developing countries' sweetpotato production, China's sweetpotato consumption has declined over the years as living standards increase. Scott (1991) estimates that 65% of sweet potato output in China goes to animal feed, principally to pigs. Sweet potato is an ideal livestock feed because the roots provide a source of energy while the leaves a source of protein, and both can be used in fresh and dried form or fermented into silage (Woolfe 1992). Sweet potato production is also substantially linked to pig production in Vietnam (Bottema 1992). A pig trial conducted in northern Vietnam indicated that better management of this sweetpotato-pig feed system may improve pig growth and increase economic efficiency (Peters(*a*), ms submitted).

As the second most important tropical root crop, sweetpotato is also processed into starch in China, mostly at household enterprise level (Marter and Timmins, 1992). During the 1980's and 1990's sweet potato starch processing has developed on a small scale in Sichuan Province and most starch is processed into noodles (Tang et al. 1990). It is estimated that, in Sichuan, five percent was processed in the 70s, and ten percent in the 80s, while increased to twenty percent in the 90s (Li et al. 1992). An economic analysis, based on a case study, shows that managed sweetpotato-pig system and starch/noodle processing have the potential of generating greater income than the current pig-raising system or sweetpotato sold for fresh market (Peters(*b*), ms submitted).

This phenomenon in China coincides with the trend in Indonesia where per capita fresh consumption declines as income increases (Gunawan 1996) and that only 16% of SP is consumed by the producers: 73.8% of production is for the market (Heriyanto 1995). Socioeconomic, agronomic, and marketing considerations for feasibility of sweetpotato flour

processing have been investigated in Indonesia to link production with processing and marketing (Peters 1997). Follow-up on-farm trials have been addressing the technical issues to ensure that the qualities of the flour meet the market requirements and the profitability satisfies the small-scale flour producers (Peters et al., ms submitted).

In the Ugandan context, sweetpotato flour production and the improved sweetpotato-pig system are two potential avenues for income generation. Traditional low-quality sweetpotato flour is milled, often mixed with cassava and/or sorghum flour, from dried sweetpotato chunks, which is processed as a means of storing sweetpotato. The farmers, however, have never marketed the flour, but occasionally sell the dried chunks at a much lower value. In addition, imported wheat flour commands a high price in Uganda (wholesale price 833 ush kg^{-1} = US$ .75[1]) and composite sweetpotato/wheat flour could reduce the price of flour. In Indonesia where subsidized wheat flour costs approximately (depending on the fluctuating exchange rate) US$.30, high quality sweetpotato flour can already offset this cost (Peters 1997), suggesting a good potential for Uganada's sweetpotato flour production. In addition, as cassava gave way to sweetpotato, pig emerged as an important livestock when cattle were robbed during the insurgence between 1987 and 1991. The unconfined pigs are mainly fed on sweetpotato roots and vines, as are in China and Vietnam. It is reasonable to investigate into the possibility of modifying and improving the current sweetpotato-pig system.

Based in Soroti County, a major sweetpotato producing area in northeastern Uganda, as a case study, the goal of this research was to examine the socio-economic, agronomic, and marketing characteristics in order to identify the appropriate post-harvest strategies for food security and income generation. Based on this goal, the research had the following objectives.

1. Identify the most important post-harvest research activities to address the issue of food security.
2. Identify the possibility and method to improve the sweetpotato-pig feed system.
3. Identify the constraints and opportunities for sweetpotato flour processing (i.e., the conditions under which it is feasible for flour processing).
4. Recommend the priorities for post-harvest activities in this area.

Methods

This research was carried out by three and a half weeks of fieldwork, preceded by one week of field study to Western Kenya and Soroti area for sweetpotato production and utilization, in November-December 1997 in three villages of Soroti County—Dokolo, Aukot, and Awoja. One group interview in each village and fifty-seven individual interviews on homesteads were administered during this period. The researcher was accompanied by an extension worker from the Soroti District Agricultural Office, and the head of the Farmers' Association of each village during all the interviews. The extension worker, who was well acquainted with almost all 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, less comprehensive market study was conducted to understand the flour and pig demands locally and nationally.

[1] US$1 = 1,100 ush (Ugandan Shilling).

The farmer questionnaire was designed to collect data on: 1) sweetpotato production, consumption, and marketing, and 2) pig production and feeding habits. While most questions were responded by farmers' recollection, daily human and pig consumption of sweetpotato was directly measured (i.e., for each homestead, a man and a woman picked out the sweetpotatoes s/he eats and the amount fed to one pig daily for weighing.) Flour market study interviewed Soroti flour wholesalers and retailers to inquire the price, sales volume, and potential for sweetpotato flour. A visit to the livestock market interviewed the district veterinarian, who is in charge of record keeping of the transactions in the market, on pig market over time.

Food Security

Sweetpotato Production and Processing

The average number of people of the homestead in the three villages ranges from 7.5 to 8.1 (Table 1). Aukot has the largest homestead size partly due to more prevalent polygamy (31% vs. 24% in Awoja and 11% in Dokolo). On average the men have 6-7 years of education in all three villages, while the women's education level varies from 2.1 years in Awoja to 4.6 years in Dokolo, with Aukot women in between with 2.3 years on average. Aukot is least densely populated and each homestead, on average, is endowed with 10.6 acres of cultivation land, while Dokolo homesteads only own 5.5 acres of land. Almost all homesteads rotate the land and leave at least a couple of acres to fallow at all time. Land rental is not costly, ranging from 5,000 to 15,000 per acre per year, depending on the relationship with land owner and the quality of the land. Some even rent more fertile land to cultivate while they have land lying fallow. On average each homestead cultivates 3 to 4 acres of land 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 acre) and Awoja (2.1 to 1.43 acre) (Table 2). The decision affecting the planting areas is affected mainly by: 1) planting material availability, 2) rain conditions, 3) labor availability. Dokolo had planting material available and increased planting area while almost all Awoja homesteads were forced purchased planting material this year. Fresh market prices of the previous year do not affect the decision for planting area because, for most, sweetpotato is an important food security crop, especially since the demise of cassava. Even for those who plant some areas specifically as a cash crop are not deterred by the low prices of the previous year due to the frequent fluctuations of the market.

When moderate rains are available throughout the sweetpotato season, the estimated yields are 4.2 ton per hectare in Dokolo, 5.1 in Aukot, and 7.4 in Awoja (Table 2). One area in Awoja is situated closed to the swamps where large herds of cattle were held, before the insurgence when almost all cattle were lost, in order to keep them from grazing on crops. The manure has made these lands quite fertile and one farmer claims that he has harvested 90 bags[2] on one acre[3] (≈24 ton/ha.), after fallow. This contributes to higher yields and more

[2] Bag is the measuring unit of sweetpotato production and sales, however, the sizes of these bags are not uniform They range between 120 - 150 kg per bag. In this report, all calculation is based on 120 kg/bag.

farmers engaging in commercial sweetpotato cultivation in Awoja. Every 3 to 4 years, there would be one year of insufficient rains and during these years productivity is reduced to 1 to 1.5 ton/ha.

During a normal year[4], sweetpotato mounds are heaped[5] during March to June, but most frequently in April and May. Those who heap for cash try 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 fall as harvests progress (Figure 1). These farmers tend to employ more labor to ensure timely heaping and planting. Others, however, constraint by lack of planting material, if depending on volunteer plants, are not able to heap as early. Thus, preparing for planting material is a way to ensure an early crop and higher yields, and to secure better market prices. As a food security crop, between July and November fresh roots are consumed with piecemeal harvests, since they cannot be stored. Once the dry season begins, the roots risk the chance of weevil attack in the ground and must be harvested. November to January is the mass harvest season when sweetpotato are also peeled and processed into *inginyo* and *amukeke* for storage. *Inginyo* is crushed chunks, which is sun dried and later consumed as *atap*, composite flour made from sweetpotato, cassava, or sorghum. *Amukeke*, on the other hand, is sliced and sun dried, which is often boiled for breakfast.

This processing procedure begins with peeling, which is labor intensive, involving more women than men. Not all roots are peeled and generally roots for *amukeke* are peeled, even though *inginyo* can be peeled. It takes approximately 24-29 man days to process one acre of mass harvest (Table 3a). However, peeling does not simply remove dirt and clean the roots, which could be easily accomplished by washing. The respondents revealed that peeling serves the important function of: 1) removing weevil-infected parts which give bad taste to both *inginyo* and *amukeke*, and also make them undesirable to pigs, 2) facilitating faster drying since peels take longer to dry, 3) making more palatable *inginyo* and *amukeke*, and *atap*. Of the three functions, removing weevil damage is of the greatest importance, which, to the farmers, justifies the heavy labor inputs and costs of hired labor.

Once peeled, an average of 70% of the roots are crushed into *Inginyo* while 30% are sliced into *amukeke*. Slicing takes skill and is often contracted out to an older man (Table 3b). It is a slow process since a large and cumbersome knife is used; while crushing, done by women only, is a faster process without requiring much skill (Table 3c). Even though a faster process, crushing requires more labor time than slicing, due to the considerably greater volume involved; , therefore, hired labor for crushing is also necessary. Even though slices can potentially be milled into flour to make *atap* like the crushed chunks, these chunks also serve other important functions that cannot be replaced by slices: 1) chunks are more resistant to weevil damage and may last 4-5 months while slices last only 3-4 months, 2) chunks pack better than slices and require less storage space, 3) *inginyo* is more marketable and profitable than *amukeke*, even though both are less profitable than fresh roots, and when in dire need of cash it is easier to sell *inginyo* than *amukeke*, and 4) chunks requires less labor than slices.

Once *inginyo* and *amukeke* are seriously damaged by weevil in April - June, they can be made into local brew called *waragi* (can be made from either sweetpotato or cassava), to save them

[3] Sweetpotato is harvested and sold in bags and each bag contains 100-120 kg of fresh roots.
[4] Due to Nino effect, 1997 has been a very abnormal year as the weather pattern was altered drastically.
[5] After plowing, approximately 5,000 individual heaps per acre are built, on which sweetpotato is planted.

from being wasted. It takes about 60 kg of *inginyo* to make 20 liters of *waragi*, which are sold for 20,000 ush. Assuming 25% of fresh root: *inginyo* conversion rate since the most common variety, *Tanzania*, contains 25-30% of dry matter content, this value yields 83 ush for one kg of fresh roots, equivalent of almost 10,000 ush per bag, a very good price indeed, considering that fresh roots were sold at 5,000 ush per bag in 1996.

Post-harvest Research Priorities

Weevil attack prevents storing sweetpotato on the ground, once harvested and processed, weevil attack again limits storage up to 4-5 months. As a result, sweetpotato, in fresh or processed form, is available for home consumption for up to only 9 months a year. This could threaten food security, especially in light of the absence of cassava. Thus, sweetpotato storage for fresh roots and processed chunks and slices must be the first priority for post-harvest activities to address food security issue.

Secondly, peeling, slicing, and crushing manually are all labor-intensive and costly activities that deserve technical assistance. Peeling cannot be assumed to be replaced by washing alone and developing technology for weevil damage removal will greatly help reduce female labor. Furthermore, developing a slicing machine will relieve labor requirements for making *amukeke*, but will not solve the labor problem for crushing. Considering that crushing is 100% women's responsibility, a crushing machine will greatly reduce women's heavy work burden.

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

Improvement of Sweetpotato-pig System

Current Practice and Status

Thirty-nine of the 57 homesteads interviewed raise pigs. The head of the Farmers' Association of each village estimates that 40% of homesteads in Dokolo, 70% in Aukot, and 80% in Awoja raise pigs (Table 4). The percentage was much higher before the alleged African Swine Fever devastated the pig population in this area in 1995-6. Pigs and sweetpotato are perceived as ways for quick turnaround cash while cattle and cassava are for the long haul and even goats take much longer before it is possible to cash them in. Tattered, but not very securely, to a tree or a stump in the shade, the pigs graze around the tree most of the day and are fed twice a day in general.

Most homesteads raise only one pig and the average number of pigs per homestead in the three villages are 1.69, 2.13, and 1.67 (Table 4). Most farmers consider pig-raising a profitable venture, but hesitate to raise more for three most common reasons: 1) not enough feed during the dry season, 2) no way of confining the pigs, 3) fear of disease, and 4) lack of cash to buy piglets. The homesteads which do not raise pigs stated similar reasons for not

raising pigs: 1) do not know how to manage and feed pigs, 2) no way of confining the pigs. Managing and confining the pigs is of great concern because a steep fine is imposed if the pigs are caught grazing on neighbor's crops.

Even though the farmers consider pig-raising profitable, pig growth is 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 4). In general, after 7-8 months of rearing, the pigs only reach 20-30 kg, after having consumed 4-500 kg of sweetpotato. These pigs are mainly fed sweetpotato roots and vines, along with other locally available feeds—brew residues, fish bones, grass, mango, and papaya—which have no cash value (Table 5). At this rate of growth, the average value of sweetpotato, calculated by the value of pigs minus the cost of piglets and divided by the kg of sweetpotato consumed during the feeding period, is as low as 24.4 ush kg^{-1} in Aukot, to 32.7 in Dokolo (because the low prices of the piglets), and 38.7 in Awoja (Table 6). These values are lower than the fresh market, which makes pig-raising not particularly profitable at these growth rates.

The following management (or lack of management) and feeding practice observed, among other factors, contribute to slow growth rate. Keep in mind 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).

- Sweetpotato roots are mostly fed fresh (Table 5) and even the cooked roots are often cooked very briefly before starch can be broken down.
- Most of the sweetpotato vines are wasted and only fed during the harvest season. Only one homestead claimed to dry and conserve the vines for the dry season.
- The vines are not chopped or cooked and whole vines are given to pigs, which eat only the leaves and do not touch the vines.
- Pigs root around the trees on which they are tattered and often are infested with worms. Most homesteads in Awoja treat worms (Table 4) while few do in Aukot, even though Awoja feeds less sweetpotato, it has the highest growth rate.
- While not confined, some pigs were observed to be tattered next to open latrines. The interactions between human feces and pigs result in tapeworms and cysticercosis.
- Many farmers attribute the slow growth to the race of pigs. This, however, needs to be tested in a trial because others have found it not to a constraint[6].
- The daily diet is not balanced and feeding is sporadic.
- Lack of protein supplement, especially in light of the sweetpotato vines, the main source of protein, is fed only during the harvest season.

Pig Market and Demand

Of all the respondents, whether raising pigs or not, none stated "lack of market" as a constraint to pig raising. Pigs in this area can be marketed three ways. First, the farmer can slaughter a pig himself and take the meat to the village market to sell by the kilo. Pork sold by the kilo commands a higher price than selling a life pig, but there is more work involved. If the farmer is not interested in engaging in the work of slaughtering and selling, he may sell

[6] An NGO in Soroti raised both foreign breed and local breed and found the growth rate to be similar, but they have since sold all the pigs, so this was not observed.

the life pig to a butcher who would offer a set price for the pig. The value is lower, but it relieves the farmer from the work. In addition to the local market, each day there is a district market in which livestock is slaughtered or sold. This market rotates around various districts in this area each day, but one is available daily.

In addition to the local and district markets, Soroti used to have access to Kampala market. The district veterinarian, who is charge of the Otuboi livestock market on Saturdays, revealed that, before the insurgence, Kampala trucks used to come to Otuboi market each Saturday to collect pigs. The local middle men would collect the pigs prior to the arrival of the city collectors with the trucks. Life pigs collected for the Kampala market offered twice the price as the local market. The pig production in this area was much high when the market was available. At that time the youths, in particular, were keen on raising pigs because the quick turnaround cash they could get. Production and sales usually peaked twice a year for Easter and Christmas. This system broke down during the insurgence, pig production fell and the Kampala market was lost. The local district office now encourages farmers to raise the pig stock again so that they may regain Kampala market. In fact, Kampala pig marketing researchers still come to this area from time to time to check on the supply level. The problem of pig industry is not demand but supply and if this area can supply enough for truck loads, the veterinarian was sure that the trucks from Kampala will soon return. Until that happens, pigs are sold in these district markets in a relative small quantity. For example, Otuboi market slaughters 15 pigs and sells 10 pigs and 15 piglets each Saturday, a total quantity of 450 kg per week. Assuming similar quantities are sold in other markets each day of the week, there is a demand of 225 pigs a week in Soroti district.

Post-harvest Activity: Proposed Integrated trial

The combination of under-achieved pig growth and potential Kampala market presents a research opportunity to modify and improve the current sweetpotato-pig practices. In light of the lack of utilization of pig manure, which could be valuable fertilizer to increase the low sweetpotato yields, an integrated research of pig trial and production trial is recommended. In the pig trial, the pigs will be confined, as one of the ways to improve growth, and the manure will be collected to apply as fertilizer in a production trial to increase yields. In China and Vietnam, pig manure serves an important function of soil maintenance and fertility and is carefully applied to increase crop productivity.

On-farm Pig Trial

A local commercial pig raiser and a veterinarian's assistant in Soroti, who has a keen interest in pig raising, conducted some 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 the report,. Epechu has further discovered cow blood from one local slaughter house, which slaughters 10 cattle each day, as a free feed. He collects 40 liters of blood a day and process it by boiling and drying. This dried blood is then mixed with maize bran and other feed, and he has noticed its positive effect on pig growth. Other smaller slaughter houses in the district also have free blood available for feed.

In addition to feeding management, Mr. Epechu believes that the exotic breed *large white* is superior to the local breed and that it achieves higher growth rate under the same diet. A local NGO, on the other hand, observed no difference of the growth between local and exotic breeds on their pig farm. The NGO also stated that commercial additive added in the diet, but a search for this additive in Soroti proved that it no longer exists. 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 trial.

These findings, along with the data collected from farmer interviews, suggest that the following four hypotheses, tested with four treatments, should be tried in an on-farm trial. These four treatments will be based on the general base diet of sweetpotato roots (fresh and dried), vines (fresh and dried), and weevil-free peels, mango, and *adakai*, 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 demands increases drastically if farmers begin using it as pig feed. Thus, a reliable but affordable supplement needs to be examined; thus, another treatment with sunflower cake, because the protein content is much higher than maize bran, should be included (Table 7). Cottonseed oil residue and soy residue, as potential protein supplements, should not be ruled out completely because they used to be common crops in this area and may appear again in the future.

Hypotheses:

H_1: Balanced diet and good management improves pig growth
H_2: Improved breed improves growth
H_3: Balanced diet enhanced with sunflower cake as supplement improves growth
H_4: Balanced diet enhanced with blood as protein supplement improves growth

Treatments:

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
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	Formulated balanced daily ration	Formulated balanced ration + sunflower cake	Formulated balanced daily ration + blood
Breed	Local breed	*Large White*	*Large White*	*Large White*
Control	Traditional practice observed everywhere	Treatment 1	Treatment 2 Treatment 4	Treatment 2 Treatment 3

During the dry season when sweetpotato vines are scarce in Vietnam, the price of vines can reach four times of that of sweetpotato roots (Peters 1997b). The Soroti homesteads, which

raise pigs, feed the vines to pigs during the harvest season and discard the rest in the field once harvest is over. Those who do not raise pigs discard all the vines in the field. These discarded vines account for much protein and fiber loss and slow growth development. 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 vine daily as the only source of protein (Peters 1997a). The large areas of sweetpotato fields should provide enough vines year round for 2-3 pigs, if dried and conserved. If it proves to be insufficient, other foliage crops with high protein content (15-20%), such as *Gracidia cipesm* , *Caliandra calianceas*, *Lucina*, *despolia*, and *lab-lab*, could be planted as supplement since almost all homesteads have excessive land.

Daily ration of balanced diet must be formulated to guide the feeding trial. For the first trial, it is recommended that the responsible extension worker weigh out the daily ration to distribute to the participating farmers to cook and feed to pigs.

Due to the distance between these three villages, it would seem logistically difficult to have participating farmers from two or three villages. If one village is to be selected, Awoja seems appropriate because the farmers there are more accustomed to cooking the feed, providing medical treatments, and feeding a more varied diet (Tables 5 & 6). Four treatments and six replications, with all four treatments in one homestead, is a manageable trial, which can be followed up by a validation trial with more replications, which lends itself more for analyzing statistical significance. Pigsty should be constructed with locally available material and attention must be paid to design which allows breeze and light in the pens, which is large enough to allow pigs to move about, and which facilitates manure collection[7].

The closest location where *large white* is available is in Tororo Prison where there is a modest breeding program. The piglets there appeared health with a shining coat of hair. Since the breeding program is modest, piglets are not always available. A few months of advanced notice for ordering piglets is essential so that they may breed specifically for the order. Pigs are advised to be raised in two seasons, and the trial should coincide with one of these two seasons (Table 8). First season begins in November when sweetpotato processing begins and dried chunks are available for the next 5 - 6 month. These pigs will be ready for Easter slaughter and avoid the May-June period when food is scarce. One drawback of this season is that it coincides with the very hot season in which pigs may lose appetite. Another season is to begin in July when piecemeal harvest begins and fresh roots are abundant. These pigs will be fed on a combination of fresh roots and dried chunks as the season progresses. After 5 - 6 months, these pigs will be ready for slaughter for Christmas.

The importance of disease control cannot be overstated. It was assumed that the disease that killed many of the pigs during 1995-6 was African Swine Fever (ASF), which is a virus that currently for which no effective vaccine is available. However, a missionary veterinarian in Soroti was not convinced that ASF was definitely 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

[7] It could be: 1) sloped with a area at the low end to collect manure, or 2) built with a gapped floor to allow dropping into a "septic tank" below the floor.

fact that there is preventative measure for cholera, but none for ASF, it is of great importance to determine the nature of the illness. 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 good management practice—confinement, de-worming, and cooked feed—will all contribute to stopping the cycle between human 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 in the interviewed area will continue to be food security. While cassava is in short supply, sweetpotato is consumed twice a day and the current production cannot satisfy 9 months of home consumption, without even considering pig feed, in Dokolo and Aukot (Table 9). 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% homesteads of Dokolo, 44% of Aukot, and 71% of Awoja claimed that they have no extra family labor for all production activities—heaping, planting, weeding, and harvesting (Table 10). Thus, in order to plant extra for commercial purpose (whether sold as fresh or processing as flour), all labor must be hired, adding costs to production. The price of sweetpotato flour must be high enough to absorb the additional costs. On average, Aukot farmers are not interested in providing a steady supply if the price is below 16,000 (133 ush kg^{-1}) ush/bag; likewise, Dokolo and Awoja farmers will only do so for less than 14,000 (116 ush kg^{-1}) or 9,700 (80 ush kg^{-1}) respectively (Table 10). Sweetpotato in Awoja has a higher yield of 7.35 ton/ha (Table 2), thus, can take a lower price. Aukot farmers, on the other hand, put a high value their time and labor[8], and feel adamant that the price must reflect this value.

Labor requirements and costs for heaping, planting, weeding, and harvesting of one acre of the home consumption crop are summarized in Tables 11a-d. Based on this labor arrangements—some family labor and some hired labor for all activities, plus the cost of renting land and oxen, total cost for one acre of production ranges from 31,722 ush in Dokolo to 43,987 ush in Aukot (Table 12). The cost of producing one kilo of sweetpotato varies with the yield. During a year with enough rain (i.e., good yields), it costs 17 ush kg^{-1} in Dokolo, 21 in Aukot, and 12 in Awoja. If all aspects of production are done by hired labor, the total production cost (including land and ox rentals) increases and the cost of one kilo increases to 27 in Awoja, 41 in Aukot, and 48 in Dokolo (Table 12). On the other hand, if the farmers engage family labor for planting and weeding, it cuts down the production cost and the per kilo cost reduces to 21, 32, and 36 ush.

Table 13 shows the analysis of the minimum raw material (fresh root) cost for flour in order: 1) for farmers to be willing to produce sweetpotato to provide a steady supply and 2) to compete with fresh market profit. If hired labor is employed for all aspects of production, the production cost for one kilo of fresh root is shown in column (a). Assuming 25% fresh

[8] 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.

root:flour conversion rate, the raw material cost, before considering profit, for one kilo of flour is shown in column (b). The minimum root price that is considered profitable, for which farmers are willing to provide steady supply, is shown in column (c). The net profit of farmers' request 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 request price. The minimum raw material cost, only to cover the production cost and alternative profit, and before taking into consideration of 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 (Dokolo), 22 (Aukot), and 11 (Awoja) ush to process one kilo of flour (Table 14). Adding the cost of the raw material with processing cost and milling cost, the minimum price of flour would have to be 323 (Dokolo), 288 (Aukot), and 182 (Awoja) in order for it to be profitable for the farmers. The reasons that the price for Awoja is considerably lower that the other two villages are: 1) high yield, 2) low labor costs, and 3) satisfied with lower price (which is related to high yield). Awoja, especially the homesteads closed to the swamp area where yields are high, seems more commercial oriented and sells more sweetpotato (Table 16). However, this could be attributed to a biased sample—almost all homesteads interviewed in Aukot and Dokolo raised pigs while only 67% of Awoja samples were pig-raisers. There could be a categorical difference in farming orientation between pig-raiser and crop-growers.

In addition to the economic consideration, the following are two environmental concerns associated with processing in this area.

- Lack of water. Most homesteads, in all three villages, must go 1-2 km to fetch clean water. Water is not a major constraint for producing for low quality flour, but would be necessary for high quality production.
- Drying facility. Crushed chunks or slices are dried on rocks if the homestead is fortunate to have access to some. Otherwise, they are dried on the ground compacted 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 of the ground and dust would need to be installed to produce cleaner flour.

Linking Flour Production with Marketing

Sweetpotato flour could be marketed as either *atap*, low-quality flour consumed by general population as a staple. Low-quality flour of cassava, sorghum, and maize are commonly traded in big volume for making *atap* and the prices of these three types of flours are 4-500 ush kg^{-1}. Usually the traders purchased dried grain or roots and have them milled; thus in Soroti, there are no wholesale buyers for already made *atap*. Sweetpotato *atap* is only observed in the market during the dry season—December- March. This year, due to the shifting weather pattern, there is little sweetpotato roots or *atap* in the market. However, even during a normal year, sweetpotato *atap* has a much more limited market. One of the only 4 or 5 traders who carry sweetpotato *atap* (the traders also purchase only dry chunks and

have them milled) revealed that during these three months, each of the 4-5 traders sell 100 kg per day—a total demand of 45,000 kg of flour and 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 sell for 150-200 ush kg^{-1} during a normal year and 250 ush kg^{-1} during famine. Low demand is the reason for such low prices, and there are two reasons for low demand. First, unlike cassava *atap*, which is a traditional food and consumed all over Uganda, consumption of sweetpotato *atap* is limited to *teso* people, the tribe living in the Soroti area, and the *Karamojon* people, and there is no market in Kampala, except among the small quantity of *teso* 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 already-made flour paint a dismal picture for sweetpotato *atap* market for the farmers. However, there is no inherent reason that sweetpotato *atap* should command lower prices than cassava and millet, but due to low demand. It is hypothesized that if the problem with African Mosaic Virus with cassava persists, sweetpotato *atap* may eventually acquire higher demands, which would result in prices approximating that 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 wholesale price of wheat flour in Uganda is 20,000 ush for a 24 kg bag, equivalent of 833 ush kg^{-1}. It is reasonable to speculate that sweetpotato flour, if accepted for wheat/sweetpotato composite flour, can command a price of approximately 550 ush kg^{-1}. At this price, it is certainly profitable to produce sweetpotato flour (Figure 2). However, three issues require further investigation before feasibility can be established. First, the requirements of sweetpotato flour quality and price must be identified. Most likely this market exists only in the three major cities of Uganda—Kampala, Jinja, and Mbale. Sample of high-quality sweetpotato flour must be distributed, with recipe, to various flour users to experiment in order to learn about their price and quality requirements. Second, if the market exists, technical issues of producing high quality flour with the acceptable color, texture, and purity (i.e., free of sand and dust in the flour) must be addressed. Three, whether the flour users would purchase flour or simply purchase fresh roots, dry chunks, or slices at low prices and process them. The owner of a bakery in Soroti, who expressed interest in substituting some wheat with sweetpotato, indicated that he would prefer to hire labor to process flour instead of buying.

Before the feasibility of processing sweetpotato flour either for *atap* or for composite flour can be established, research efforts of selecting for high yielding varieties with high dry matter content can improve profitability and make flour processing at least economically feasible. Concurrently, research efforts should be oriented to understanding the shifting pattern between sweetpotato and cassava in order to project to what extend sweetpotato may substitute the role of cassava. Such understanding helps determine whether sweetpotato is facing the opportunity of becoming a major crop for both food security and processing or it is simply filling in until cassava recovers its strength. The most important of all is to learn

whether flour users are interested and whether they would be willing to purchased already made flour.

Conclusions: Overall Strategic Priorities

- For food security, the priorities lie within developing technology for crushing, slicing, addressing the issue of weevil-damage removal, fresh root and processed *inginyo* and *amukeke* storage.
- Farmers are keen on raising pig and on learning 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 appear feasible on a commercial-scale. Thus, post-harvest activities for income-generation should first focus on pig production (i.e., a pig trial). The trial should be set to July when piecemeal harvest begins. Concurrently, an organic fertilizer trial, utilizing the manure from the confined pigs, should be conducted on farm. The results of the trial on growth and cost effectiveness will be used to compare with the potential profit of flour production to inform the next step of activity. In addition, dried sweetpotato vines must be incorporated into the trial to test the effect of added volume of vines in the diet and demonstrate the use of dried vines to the farmers. The pig trial should be integrated with a fertilizer trial, using the manure or compost made from the manure, to improve productivity.
- While post-harvest efforts focusing on pig production, breeding program for selection and introduction of high DM and/or yielding varieties may be conducted concurrently to improve the profitability of potential flour production. In addition to focusing on increasing profitability, the issue of marketability also must be addressed by understanding the flour users' willingness to pay and their requirements of the quality of the flour.

References

Bashaasha, B., R.O.M. Mwanga, C. Ocitti p'Obwoya, and P.T. Ewell. 1995. Sweetpotato in the Farming and Food System of Uganda: A Farm Survey Report. International Potato Center, Sub-Saharan Region, Nairobi, Kenya.

Bottema, Taco. 1992. Rapid Market Appraisal, Issues and Expereince with Sweetpotato in Vietnam. *In* Scott, G., S. Wiersema, and P. I. Ferguson (eds.) *Product Development for Root and Tuber Crops, Vol. 1- Asia.* International Potato Center, Lima, Peru.

Callis, J. J., A. H. Dardiri, D. H Ferris, G. G. Juan, J. Mason, and F. W. Wilder. 1982. Illustrated Manual for the Recognition and Diagnosis of Certain Animal Diseases. Mexico-United States Commission for the Prevention of Foot and Mouth Disease. Plum Island Animal Disease Center.

Goodman, D. E. 1994. *Raising Healthy Pigs under Primitive Conditions.* Third edition revised. Christian Veterinary Mission, Seattle, WA.

Gunawan, M. 1996. Current situation and future prospects for sweetpotatoes in Indonesia (draft). CIP, Bogor, Indonesia.

Heriyanto. 1995. The opportunity of sweet potato development on irrigated areas: Study of production, marketing and farmers' decision making in East Java Province (in Indonesian). PhD thesis Padjadjaran University, Bandung, Indonesia.

Holland, D. E., M. D. Slman, J. K. Flanagan, J. B. Pilcher, and V. C. W. Tsang. 1995. Cysticercosis in Haiti in 1995: Seroprevalence and epidemiological characteristics. Center of Veterinary Epidemiology and Animal Disease Surveillance systems, Collage of Veterinary Medicine and Biomedical Sciences, Colorado State University, Ft. Collins, CO.

Jurgens, M. H. 1993. *Animal Feeding and Nutrition.* Seventh edition. Kendall/Hunt Publishing Company.

Li, Wei Ge, W. Xiuqin, Cai Huiyi, and Du Rong. 1992. Sweetpotato in China. *In* Product Development for Root and Tuber Crop, Volume 1 - Asia. Greg Scott, Siert Wiersema, and Princess Ferguson (eds.). International Potato Center, Lima, Peru.

Marter, A. D. & Timmins, W. H. (1992) Small scale processing of sweet potato in Sichuan province, People's Republic of China. J. Trop. Sci. 32: 241-250.

Okoth, J. R. and W. Epechu. A study of the possibility of commercial pig rearing based on a sweetptoato feed system. A report submitted to CIP-Kampala, Kampala, Uganda.

Peters(*a*), D. (ms submitted). Improving small-scale livestock production in developing countries: The case of pig production in northern Vietnam.

Peters(*b*), D. (ms submitted). Sweetpotato Processing for Poverty alleviation and Rural Stability: A Case Study of Yilong County in Sichuan, China.

Peters, D. 1997a. Trip report to Vietam (4/1997). CIP-ESEAP, Bogor, Indonesia.

Peters, D. 1997b. Trip report to Vietnam (8-9/1997). CIP-ESEAP, Bogor, Indonesia.

Peters D. and C. Wheatley. 1997. Small scale agro-enterprises provide opportunities for income generation: Sweetpotato flour in East Java, Indonesia. *Quarterly Journal of International Agriculture* (in press).

Peters, D., C. Wheatley, Heriyanto, and Antarlina. (ms submitted). Participatory process improvement for small scale sweetpotato flour production in East Java, Indonesia.

Scott, Greggory J. 1991. Sweet Potato as Animal Feed in Developing Countries: Present Patterns and Future Prospects. Paper presented at the FAO Expert Consultation on The Use of Roots, Tubers, and Plantains, and Bananas in Animal Feeding. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, 21-25 January.

Tang Z., Lin, L., Li, R., Wan Y., and M. Fu (1990) SP utilization and Processing in Sichuan (CIP working paper No. 89-15) In: potato and SP research in China 1986-1989, CIP region VIII, Bejing, China, pp89-104.

Woolfe, Jennifer A. 1992. *Sweet Potato: An Untapped Food Resource*. New York, NY: Cambridge University Press.

Table 1. Average number of people per homestead and the education level of the heads of the homestead in three villages.

		Cultivation land (Acre)		Number of people per homestead		Education of homestead heads	
Village	# of respondent	Total	Currently cultivated		Total number	Man	Woman
Dokolo	20	5.5	3.67	5.84	7.6	6.7	4.6
Aukot	16	10.6	4.63	6.08	8.1	6.1	2.3
Awoja	21	7	4.57	5.6	7.5	5.9	2.1

Table 2. Characteristics of sweetpotato production in three villages.

	Planting area (acre)		Yield (ton/ha.)		1997 Production (ton)		Planting and harvesting calendar (month)		
Village	1996	1997	Enough rain	Lack of rain	Enough rain	Lack of rain	Plant	Piece-meal	Mass harvest
Dokolo	1.1	1.37	4.2	1.6	2.8	1.05	3-5	6-11	10-1
Aukot	1.7	1.22	5.1	1.8	2.8	1.08	3-6	6- 1	10-1
Awoja	2.1	1.43	7.4	2.6	4.7	1.5	3-6	7-11	11-1

* The yield and production are estimated based on 120 kg per bag of sweetpotato since the unit of measure is one bag of sweetpotato containing 100-120 kg.

Table 3a. Labor requirements and costs for one acre of sweetpotato processing: peeling.

Village	% HS use both m/w	% HS only women	# of hired labor	# of family labor	Total man days (#)	Total cost (ush)
Dokolo	22	78	5.4	2.7	29.3	13,700
Aukot	50	50	2.7	3.4	27	9,693
Awoja	29	81	.2	2.7	24	5,883

Table 3b. Labor requirements and costs for one acre of sweetpotato processing: slicing.

Village	% HS use men only	# of hired labor	# of family labor	Total man days (#)	Total cost (ush)
Dokolo	100	.22	1.6	6.9	467
Aukot	100	1.81	1.2	12.6	7,375
Awoja	100	.7	.7	7	3,265

Table 3c. Labor requirements and costs for one acre of sweetpotato processing: crushing.

Village	% HS use women only	# of hired labor	# of family labor	Total man days (#)	Total cost (ush)
Dokolo	100	1.5	4.8	28.5	3,950
Aukot	100	1.8	1.9	14.9	5,120
Awoja	100	.9	2.2	14.5	1,974

Table 4. Characteristics of pig raising in three villages.

Village	HS (no)	HS with pigs (%)	Pig/HS (no)	1 pig/HS (%)	Month (no)	Beg.wt (kg)	End wt (kg)	Monthly growth	Treat worm (%)
Dokolo	13	40	1.69	69	7.6	3.1	29.7	3.45	46
Aukot	14	70	2.13	42	7.9	3.4	19.9	2.11	29
Awoja	12	80	1.67	67	7.8	4	23.9	2.7	83

Table 5. Pig feeding practices in three villages.

Village	SP roots (kg)	HS cook SP (%)	HS save vines[a] (%)	HS feed peels (%)	HS feed *adakai*[b] (%)	HS feed *ting*[c] (%)
Dokolo	2.66	23	0	23	46	--
Aukot	2.41	29	0	71	57	57
Awoja	1.94	100	8	92	75	75

[a] Sweetptoato vines are normally fed to pigs during harvest period and once the harvest is over, the vines are discarded in the field.
[b] *Adakai* is the residue of alcohol brewed from millet.
[c] *Ting* is the residue from brewing *waragi*.

Table 6. The value of sweetpotato when fed to pigs and converted into pig value.

Village	Daily SP feed (kg/day)	Month (no)	Value of pig[a] (ush)	Piglet cost (ush)	Value of SP (ush/kg)
Dokolo	2.66	7.6	23,455	3,346	32.7
Aukot	2.41	7.9	17,533	6,233	24.4
Awoja	1.94	7.8	23,333	7,077	38.7

[a] Data from survey, estimated by farmers and butchers.

Table 7. Digestible crude protein content available to pigs of various feed supplements.

Feed	dCP (%)
Blood meal	89
Sunflower cake	45
Maize bran	9
Cottonseed oil	41
Soy bean meal	45

Source: Jurgens 1993.

Table 8. Two seasons for raising pigs in Soroti.

	Easter Pigs	Christmas Pigs
Begin	November (processing begins and *inginyo* available)	July (piecemeal harvest begins and fresh roots available)
Finish	Easter	Christmas
Diet	Dried roots (*Inginyo* or *amukeke*)	Fresh roots (July - November) Dried roots (Nov. - Dec.)
Advantage	Finishes before food shortage	Begins after food shortage season
Disadvantage	Coincides with hot season, pigs may lose appetite during this time.	

Table 9. Sweetpotato consumption of each homestead in three villages.

Village	Person (kg/day)	Homestead (kg/day)	HS 9 mo. (kg/9 mo)[a]	Waragi (kg/year)	Year total (kg/year)	Extra SP[b]
Dokolo	2.1	12.8	3,508	740	3,952	-1,176
Aukot	1.9	11.8	3,248	555	4,866	-2,032
Awoja	1.7	8	2,293	211	3,542	1,287

[b] Amount of sweetpotato left, after home consumption and making waragi, for other uses, such as pig feed and market (1997 production minus year total consumption).
[a] Due to storage problem of processed *inginyo* and *amukeke*, sweetpotato is only available for 9 - 10 months of consumption a year.

Table 10. Labor availability for planting extra sweetpotato for commercial purpose and the price requirements to justify the extra labor inputs.

Village	HS with no extra family labor (%)	HS with extra labor for planting and weeding (%)	Minimum price to "heap for cash" (ush/kg)
Dokolo	67	33	116
Aukot	44	56	133
Awoja	82	18	80

Table 11a. Labor requirements and costs for one acre of sweetpotato production: heaping.

Village	% HS use both m/w	% HS use only men	# of hired labor	# of family labor	Total man days (#)	Total cost (ush)
Dokolo	78	22	3	3.3	29.1	11,500
Aukot	89	19	2.9	3.1	28.7	14,719
Awoja	57	43	4.1	2.3	25.3	14,785

Table 11b. Labor requirements and costs for one acre of sweetpotato production: planting[a].

Village	% HS use both m/w	% HS use only men	% HS use only women	# of hired labor	# of family labor	Total man days (#)	Total cost (ush)
Dokolo	100	0	0	.3	3.8	9	222
Aukot	81	13	6	1.4	3.7	15.3	2,094
Awoja	72	14	14	1.3	3.6	16.2	1,211

[a] Planting is often done on the same days as heaping and the labor and costs are often difficult to separate from heaping.

Table 11c. Labor requirements and costs for one acre of sweetpotato production: weeding.

Village	% HS use both m/w	% HS use only men	# of hired labor	# of family labor	Total man days (#)	Total cost (ush)
Dokolo	78	22	1.2	4	15	2,244
Aukot	75	25	2	3.6	24.7	5,006
Awoja	43	43	2.5	2.8	21.7	6,233

Table 11d. Labor requirements and costs for one acre of sweetpotato production: harvesting.

Village	% HS use both m/w	% HS use only men	# of hired labor	# of family labor	Total man days (#)	Total cost (ush)
Dokolo	89	11	3.7	3.7	25.33	11,700
Aukot	75	25	2.8	3.1	23.81	11,480
Awoja	43	57	2.2	2.3	17.95	7,119

Table 12. The cost of producing one kilo of sweetpotato under the current labor arrangement, all hired labor, or hired labor for plowing, heaping, and harvesting only.

	Current labor arrangement		All hired labor		Partially hired labor	
Village	Total cost per acre (ush/ac)	Cost for 1 kg (ush/kg)	Total cost per acre (ush/ac)	Cost for 1 kg (ush/kg)	Total cost per acre (ush/ac)	Cost for 1 kg (ush/kg)
Dokolo	31,722	17	81,812	49	60,812	36
Aukot	43,987	21	89,688	41	68,687	32
Awoja	37,781	12	83,547	27	62,547	21

Table 13. The minimum flour price in order to compete with the profit from selling fresh roots.

	Production cost (based on all hired labor) (a)	Raw material for flour production cost (b)	Root prices at which farmers will provide stable supply (c)	Net profit for farmers at their requested prices (d)	The minimum price for flour to compete with fresh root (e)
Dokolo	49	196	116	87	283
Aukot	41	164	133	92	256
Awoja	27	108	80	53	161

a) See Table 12.
b) Assuming 25% fresh root:flour conversion rate, b = a * 4
c) See Table 10.
d) d = c (sale price) - a (production cost)
e) e = b (raw material cost for flour production) + d (net profit farmers could get from selling fresh roots).

Table 14. Processing costs of peeling and crushing per kilo of sweetpotato flour, based on all hired labor cost.

	Peeling labor		Crushing labor					
Village	Man day (#/ac) (1)	Cost (ush/p/d) (2)	Man day (#/acr) (3)	Cost (ush/p/d) (4)	Total Cost (ush/acr) (5)	Produ-ction (kg/ac)	Processe d (kg/ac) (7)	Processi ng cost (ush/kg)
Dokolo	29	860	29	600	42,340	2,028	1,420	30
Aukot	27	844	15	850	35,538	2,316	1,621	22
Awoja	24	630	15	657	24,975	3,348	2,343	11

For (1), (3), see Tables 3a & 3c.
(5) = (1) * (2) + (3) * (4)
(6) = (6) * .7 (70% roots are crushed)
(7) = (5) / (7)

Table 15. Minimum price of sweetpotato flour in order for the farmer/processor.

Village	Raw material cost (ush/kg)	Processing cost (ush/kg)	Milling cost (ush/kg)	Total cost/flour price
Dokolo	283	30	10	323
Aukot	256	22	10	288
Awoja	161	11	10	182

Table 16. The number of homesteads selling sweetpotato roots in 1996 and 1997 in three villages.

	1996 Sales		1997 Sales	
Village	% HS sold	# bags	% HS will sell	# bags
Dokolo	30	3.8	5	
Aukot	63	4.7	0	
Awoja	95	22.8	38	

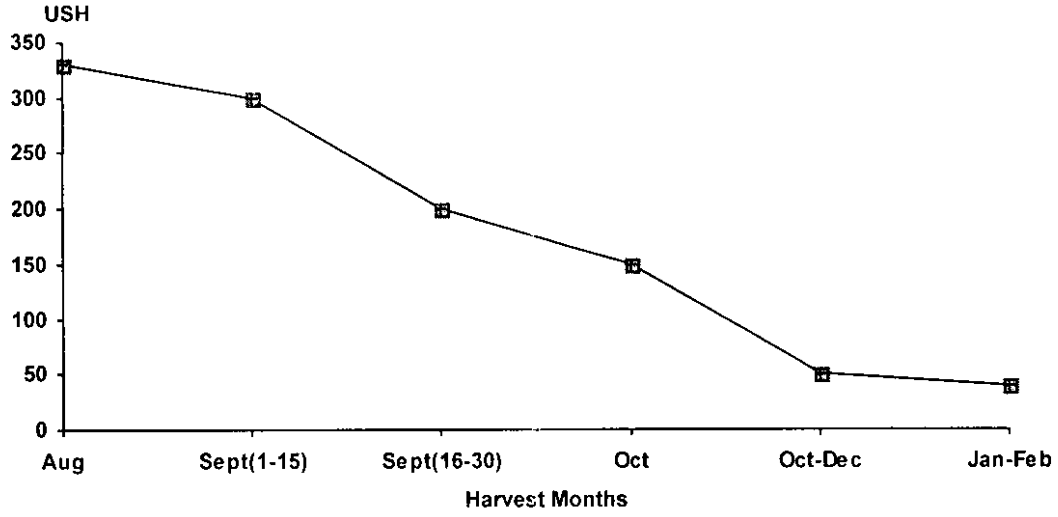

Figure 1. Sweetpotato price (kg^{-1}) fluctuations during the harvest months in 1996 in Soroti.

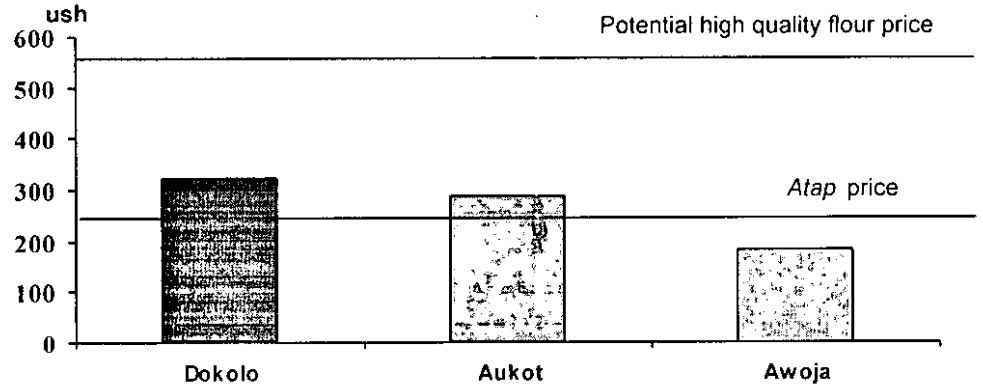

Figure 2. Sweetpotato flour production costs in three villages, as compared with the price of low-quality flour (*atap*) and the potential price of high quality flour.