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Sweetpotato Postharvest Systems in Uganda: Strategies, Constraints, and Potentials

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Abstract

Sweetpotato is often either a major food staple or complementary staple in Ugandan food systems. It also serves as a famine reserve crop and increasingly as an important source of case income. Nevertheless, sweetpotato has only recently begun to attract the attention of researchers and policy makers with much of that effort focused on production-related issues. Using needs assessment survey methods, this study identifies constraints and opportunities in the current sweetpotato postharvest systems in Uganda. It also reports on efforts to improve storage of fresh roots and analyzes processing options. Commonly held dubious notions regarding sweetpotato marketing are briefly examined. The findings presented do not conform to widely held beliefs. Prospects for sweetpotato product development are explored using the example of sweetpotato bread. This paper concludes that development of sweetpotato in Uganda will require more attention to postharvest systems and that postharvest research would benefit from, among other things, capacity-building in the marketing and small agro-enterprise area.

Resumen

En los sistemas alimenticios de Uganda, frecuentemente se usa el camote como cultivo alimenticio básico o como principal alimento complementario. También es utilizado como un cultivo de reserva contra la hambruna y constituye una fuente importante de ingresos con su venta en pequeña escala. No obstante su importancia, el camote está concitando la atención de investigadores y políticos sólo recientemente. La mayoría de los esfuerzos hasta la fecha están relacionados con actividades productivas. El presente estudio utiliza el método de sondeo de la evaluación de necesidades para identificar los factores limitantes y las oportunidades de los sistemas de poscosecha de camote vigentes en Uganda. Presenta, igualmente, los resultados de los esfuerzos por mejorar el almacenamiento de raíces frescas y examina brevemente la comercialización del camote. De otro lado, también se plantean alternativas para desarrollar nuevos productos, utilizando como ejemplo el pan de camote. El estudio concluye afirmando que para desarrollar el camote en Uganda se requerirá poner mayor atención a los sistemas de poscosecha y que la investigación sobre el tema podría beneficiar de capacitación en el área de comercialización y el desarrollo de la pequeña agro-industria.

Editor's note

Much of the information reported on in this working paper documents field results that were gathered in 1993 and 1994. Recent changes in production of food crops in Uganda since then suggest that some of the observations made in this study may require reconsideration. The original results are printed here for wider dissemination to help contribute to the creation of a body of knowledge on sweetpotato in Uganda. In so doing this report also aims to facilitate research on sweetpotato currently on-going or planned for the near future.

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Acronyms and Abbreviations

ACMVD	African Cassava Mosaic Virus Disease
CIP	International Potato Center
DDF	Kumi District Development Fund
ha	hectare
IGSPH	in-ground storage and piecemeal harvesting
ISNAR	International Service for National Agricultural Research
IARCs	International Agricultural Research Centers
kg	kilogram
MUKLA	Makerere University at Kampala
NARO	National Agricultural Research Organization
NARS	national agricultural research system
NGSS	non-grain starchy staples
NRI	Natural Resources Institute, UK
NRI-NGSS	Natural Resources Institute – Non-Grain Starchy Staples Project
SDS	storage of dried sweetpotato
t	metric ton (1,000 kg, 2,200 lbs.)
USh	Ugandan Shillings (US$1 =1,000)

1. Introduction

Sweetpotato is a major food staple in Uganda, grown throughout the county both as a subsistence food crop and increasingly as a cash crop supplying local institutions (schools, hospitals, and prisons) as well as consumers in the urban centers. Sweetpotato serves as a dietary staple for many subsistence farmers, as well as low-income groups in urban areas, particularly Kampala (Mwesigwa, 1995).

Production estimates suggest that in 1992 170,000 ha of the crop was cultivated, producing around 1.4 million metric tons (t), compared to 4.0 million t for matooke, 5.0 million t for cassava, and 0.5 million t for maize (MAAIF, 1992). Although the production of sweetpotato is unevenly distributed throughout the country, most rural households have at least one small plot (< 0.5 ha). Sweetpotato has been part of traditional Ugandan cropping systems for at least the past century, however, it has only recently begun to receive attention by researchers and policy makers.

In Uganda, sweetpotato is generally perceived as a poor man's food or as a famine food and consequently the crop has captured little research interest. Attention has begun to focus on the crop due to the realization that it plays a major food security role for subsistence farmers and urban consumers both in Uganda and throughout the region. Additional reasons to justify research on sweetpotato include:

- It is increasingly being grown as a cash crop for sale as cheap food to the urban poor.
- It is well suited to East African farming systems requiring limited inputs, including labor, and showing a degree of drought tolerance.
- In subsistence production, it is identified as a woman's crop.
- The decline in production of cassava, and to a lesser extent matooke, has increased the importance of sweetpotato as a starchy staple. This has presented new utilization challenges.

Postharvest issues associated with the crop are particularly important as its consumption and utilization roles continue to evolve. In part this is due to the decline of other crops, as well as the potential created for the crop in the prevailing dynamic economic environment in the country.

Current research on sweetpotato in Uganda is focused in the National Post-Harvest Programme, and the National Sweetpotato Programme. The profile of research on sweetpotato in these national institutions has in recent years been raised by collaborative work with both the Natural Resources Institute (NRI), UK, and the International Potato Center (CIP). The National Sweetpotato Programme is actively pursuing research focusing on production technology. Clearly, this work needs to be linked with relevant postharvest research.

A comprehensive report on the role of the crop in the food systems of Uganda (Bashaasha et al., 1995) highlighted a number of important constraints to both production and postharvest. Most notably, this report highlighted the fact that "...sweetpotato is perishable with a very short shelf-life and postharvest storage is virtually non-existent" (p. 62, Ibid.).[1] A recent study of the crop by NRI (Fowler and Stabrawa, 1993) again emphasized that many of the marketing problems faced by the crop are exacerbated by its "highly perishable nature."

Policy decisions in the National Agricultural Research Organization (NARO) have identified both sweetpotato and postharvest as priority areas of research (MAAIF, 1995). Work on postharvest is also consistent with current national objectives to strengthen agricultural production and food security, to increase small farmer incomes, and to reduce the cost of basic foods in the hope of controlling inflation (World Bank, 1993).

Whereas postharvest may be an area where sweetpotato would benefit from research and subsequent technical interventions, such efforts need to focus more closely on the precise nature of problems and constraints, as well as to look at potential utilization opportunities. Of particular concern is that research agendas appear to have been blinded by the perishability of the crop and the underlying assumption that postharvest losses associated with sweetpotato are necessarily high. The assumption that traditional postharvest systems are inefficient was discredited a decade ago (for example, by Greeley, 1987, 1991). Clearly, there is a need to analyze more carefully traditional postharvest systems and identify precisely where and how technical or policy interventions can really help improve existing practices.

Another trajectory that postharvest research looks set to follow is the development of sweetpotato processed products. The rationale being that the crop is in a production and utilization niche that can only be expanded by broadening its utilization base. In a culture with deeply entrenched and conservative food habits, this could present a significant research challenge.

Sweetpotato postharvest research is at a relatively early stage and resources are limited. Given this situation, this study provides some policy options based on a combination of intensive case studies (needs assessment)[2] of sweetpotato postharvest systems in the country; pilot testing of post-harvest technology to address postharvest constraints; and the testing of potential novel product development options. These studies are placed in the context of the needs and aspirations of farmers, their farming systems, and urban consumers as well as the more general context of the Ugandan economy and relevant institutional issues in the national agricultural research system.

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[1] Although this study highlights the perishable nature of the crop, it provides no estimation of postharvest losses resulting from this characteristic under prevailing farm practices.

[2] Needs assessment surveys are diagnostic surveys using informal methods to identify options for technical intervention and researchable constraints (Gilling and Cropley 1993).

Objectives

The core of this study is based on a needs assessment survey to identify postharvest constraints faced by sweetpotato farmers and rural consumers. Results of this survey are used as the contextual perspective to explore future potential utilization options for sweetpotato in the food systems of Uganda. The broad objective is to devise research and technology transfer options which appropriately address the constraints and potential utilization options identified. The findings of the needs assessment are supplemented by reporting on pilot testing of technologies which address some of the identified constraints and potentials. The specific objectives of the needs assessment were to:

- Identify the role of sweetpotato in farming and food systems, and the socio-economic and geographical determinants of this role.
- Review existing farm-level postharvest practices as well as identify losses and storage constraints and their relative importance in the wider socio-economic and cropping context of the farmer.
- Determine features of the marketing system; in particular, examine access to markets, seasonal price/demand features, and the influence of risk on pricing decisions by wholesalers and retailers.
- Assess the level and value of losses at different points in the marketing chain.

Organization of the Report

This report is divided into nine chapters beginning with the Introduction. Chapter 2 outlines the specific objectives of this study, the research methods used and provides the reader with a brief orientation regarding the systems concepts used in subsequent discussion. Chapter 3 describes and analyses the national context, focusing on the nature of the currently dynamic economy and institutional issues associated with the rehabilitation and restructuring of the Ugandan agricultural research system. Chapter 4 reviews the role of sweetpotato in the food systems of Uganda and demonstrates that sweetpotato is in fact part of a diverse and complex food and food security system. This chapter also highlights the relative importance of the crop in the context of these systems and their regional distribution. Chapter 5 describes the major postharvest systems associated with sweetpotato and their associated constraints. Chapter 6 examines selected issues in the marketing chain for sweetpotato; particular emphasis is given to questioning, if not dispelling, a number of dubious notions concerning marketing practices which tend to mislead research policy. Chapter 7 examines pilot testing of small-scale storage technology for fresh sweetpotato designed for the semi-subsistence production sector. Chapter 8 reviews the potential for increasing and diversifying

utilization of sweetpotato and the attendant problems and constraints. Finally, Chapter 9 synthesizes the major findings of this study.

The constraints and potentials identified in the postharvest systems examined are then used as the basis for recommendations for future research. This includes three aspects: geographic focus; technical direction; and institutional issues and their implications for the scope of future postharvest research and the focus of capacity-building.

2. Research Approach

This report presents information from three main sources. It draws initially on the results of a needs assessment survey which collected information from specific sites in eight districts. The report does not attempt to present all the data collected in the eight districts, but uses selected information to illustrate the postharvest systems in Uganda. (This study was undertaken by the author in collaboration with the National Post-Harvest Programme as part of the NRI-NGSS [Natural Resources Institute-Non-Grain Starchy Staples Project] in Uganda, see Hall, forthcoming).

The report also sets forth the results of on-station and on-farm pilot testing of small-scale storage technology for fresh sweetpotato designed for the semi-subsistence producer. On-station trials were undertaken by NRI (see Devereau, 1995 and 1996) in collaboration with the staff of the National Post-Harvest Programme and of Serere Agricultural Research Station as part of the NRI-NGSS project in Uganda. On-farm pilot testing was undertaken by the author in collaboration with the staff of the National Post-Harvest Programme and the Soroti District Agricultural Extension Office, also as part of the NRI-NGSS Ugandan project.

The third source consists of the results from pilot-testing sweetpotato products. This research was part of a sister study on the potential demand for sweetpotato processed products, a joint investigation under the NRI-NGSS project in Uganda and CIP-Nairobi (see Hall, Hagenimana, and Low, forthcoming).

The remainder of this chapter examines more carefully the research approach used for the needs assessment survey. The methods used for the pilot testing of technologies is described in later chapters.

Needs Assessment

A needs assessment is essentially an agricultural research planning and policy exercise (Gilling and Cropley, 1993). The needs assessment method relies on a mixture of informal research methods[3] and secondary data. The use of these methods is an attempt to avoid the narrow focus and heavily weighted preconception concerning the nature of agricultural problems that historically have occurred in the planning and policy

[3] Informal methods of information collection refer to i) group discussions with farmers; ii) rapid rural appraisal (RRA) methods; and iii) participatory rural appraisal (PRA). Complete descriptions of these methods can be found in IIED (1988), World Resources Institute (1991), and Chambers (1992).

phase of agricultural research.[4] The primary objective of needs assessment is to influence technology policy, technology choice, and applied research in such a way that subsequent technological interventions are focused on pertinent needs and constraints of farmers. By identifying and addressing farmers' needs and constraints in this way, there is a greater likelihood that subsequent technological interventions will be readily adopted.

This approach is particularly relevant to postharvest technology interventions where technical competence has been high, but where adoption rates have been low (see, e.g., Greeley, 1982 and 1987). In the case of sweetpotato, many technical options for postharvest technology are already available. Much less is known about which type of intervention will genuinely assist farmers (and/or consumers) and will therefore achieve a significant degree of adoption and, consequently, impact. This process of technology choice and adaptation to meet local conditions is, for historical reasons, weak in the Ugandan national research system (see discussion in Chapter 3). The postharvest sector presents considerable challenges for the process of appropriate technology choice. Many of these challenges arise due to the complexities of the interrelated nature of the food and farming systems. Needs assessment provides an approach which is well suited to dealing with these complexities at the farm level. The introduction and application of needs assessment methods was part of the wider process to support and develop a capacity to exploit "on-the-shelf" technologies.

Needs Assessment: Case Study Approach

Site selection was based on pre-survey visits to several districts, during which sites were identified that would illustrate the different food system roles and associated post-harvest constraints of sweetpotato. The eight sites selected for the needs assessment surveys were Luwero District, Buruli County; Mbarara District, Isingoiro County; Iganga District, Bunya County; Kabale District, Rubanda County; Kabarole District, Mwenge County; Kumi District, Kumi County; Masindi District, Bujenje County; and Soroti District, Soroti County.

Each of the eight study sites represents a case study, i.e. an intensive examination of the postharvest processes (with a focus on sweetpotato) in a particular village or community. The case studies were not necessarily indicative of the situation in the

[4] Many of these problems arose because the information has historically been collected by questionnaire survey. Although questionnaires in themselves are a valid research method, their use in understanding phenomena at the agriculture/social interface is limited. In particular, the logic of sampling, which is often used to justify these methods, is inconsistent with the diversity of what are essentially social phenomena. (For further discussion see, e.g., Chambers and Ghildyal, 1985; Inglis, 1992; and Chambers, 1992.) However, the wheel may now have turned full circle as there is increasing criticism of some aspects of PRA, e.g., Hall and Nahdy, 1999.

whole district,[5] although it was possible to make some generalizations. This approach was adopted because existing literature on sweetpotato in Uganda (e.g., Bashaasha et al., 1995) adequately documents the general features of the sweetpotato production and postharvest systems in the districts. However, there remained a need to focus more closely on specific components, in particular, postharvest.

Systems approach and concepts

The research undertaken for this study adopted a systems approach in recognition of the multi-dimensional nature of factors conditioning sweetpotato constraints and potential. Production and consumption factors can not be considered to be acting independently – this is very clearly the case at the farm level. It is necessary to capture and account for the complexities arising from the interaction of these two spheres of activity. Furthermore, it is not just sweetpotato production and consumption which needs to be considered, but broader aspects of these systems (other commodities and opportunities) and the interaction of these with those of sweetpotato.

At its simplest level, the systems approach recognizes that there is an intersection and therefore interaction between **farming systems** (production) and **food systems** (consumption). For the purposes of this study, **farming systems** are viewed as a horizontal concept including all aspects of rural activity associated with agricultural production. **Food systems** being viewed as a vertical concept, including all aspects of activity from production, through the marketing chain to the consumer (both urban and rural), including any processing and value-added activities.

In addition to these two major systems the research also recognizes postharvest activities as a distinct system, but one which falls within and interacts with both food and farming systems. For the purposes of this study, postharvest systems are viewed as both a vertical and horizontal concept, cutting across food and farming systems, but also representing a hierarchy of activity in the food system. There are **farm-level postharvest systems** including harvesting, storage, processing and consumption/utilization; **market-chain postharvest systems** including traders, middlemen, transportation, wholesalers and markets; and **consumer-level postharvest systems** which include processing and consumption/utilization.

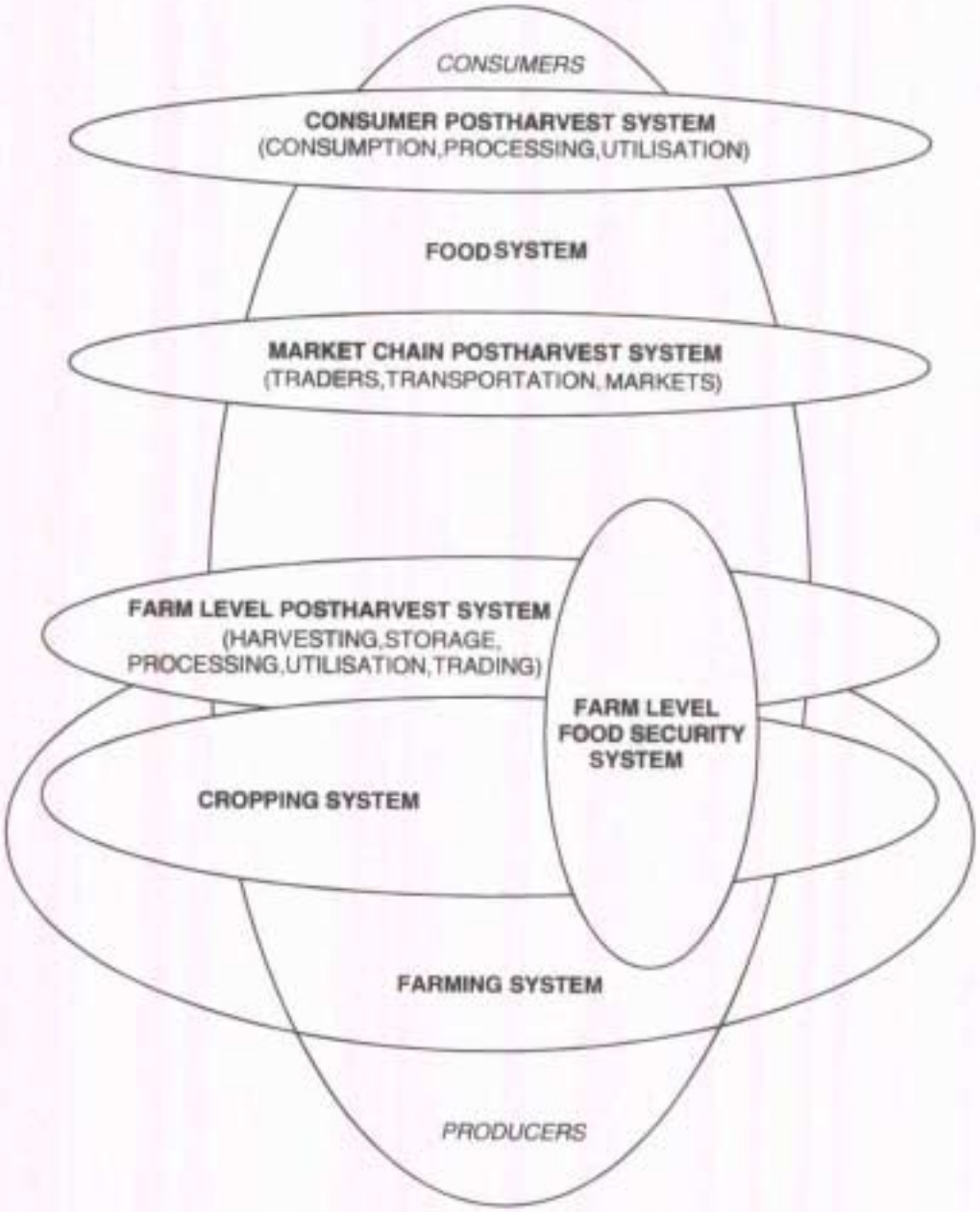
Two other subsystems are also recognized in this study: the **cropping system**, a component of the farming system, which includes the activities and strategies associated with crop production and the mixture of crops produced; and the **farm-level**

[5] During the course of the needs assessment survey, it was apparent that agricultural contexts within districts show great diversity. This has long been recognized as an important feature of the agricultural production environment (Biggs and Clay, 1981). The consequence of this is that research findings and recommendations can only be made with any degree of certainty about the specific case study site. Nevertheless, the case study approach is recognized as an effective way of understanding rural phenomena, particularly for identifying patterns, commonalities and empirical regularities (Lipton and Moore, 1972; Yin, 1984). In the remainder of this report, although the text will discuss needs assessment findings in a particular district, these actually refer specifically to the case study site.

food security system, as a component of the food system, which specifically includes the mutually supportive components for the farming, cropping and farm-level postharvest system, as well as aspects of the market (food systems) which contribute to overall household food security—i.e. strategies rural households adopt to gain access to adequate supplies of food throughout the year.

The interrelationship of these systems and subsystems is presented in Figure 2.1 to aid reader orientation. Using this systems perspective and the case study approach

Figure 2.1 Systems perspective for examining sweetpotato postharvest constraints and opportunities.



described above, Chapters 4 and 5 of this report present a synthesis of the needs assessment survey. This describes the farm level postharvest systems of sweetpotato in the context of different cropping systems in the country; the role of sweetpotato in the food security systems in these specific contexts; and the implications of the interrelationship between cropping, postharvest and food security systems. This is used to identify constraints in the postharvest system of the crop, their relative importance and highlights potential opportunities for improving sweetpotato utilization. By using the systems perspective described, the study aims to distinguish between sweetpotato postharvest constraints and potentials which were important in the context of food and food security systems rather than just being important from a single commodity perspective.

Chapter 6 explores the realities of adaptive testing and transfer of postharvest technology into the complexities of the farming system. Having understood the issues at the farm level, the constraints and potentials of sweetpotato are then examined in the context of the wider food system. Namely, the marketing chain linking producers to consumers and the postharvest systems operating at these two levels are discussed in Chapters 7 and 8.

Gender and Social Stratification

Pre-survey field visits confirmed that women play the dominant role in sweetpotato production. Women undertake most of the production activities: planting, weeding, and harvesting. On-farm postharvest activities (peeling, slicing drying and cooking) are also strictly the woman's domain. Men generally play a significant role only in marketing and the commercial aspects, transport and sales transactions. Gender issues were addressed in the survey methodology by focusing on women in the farm-level interviews, whereas men were interviewed to identify aspects of the marketing process. In practice, it was actually quite difficult to separate men and women, particularly in group meetings and informal discussions. However, researchers developed a number of tactics to improve their ability to collect information from women.[6] In the remainder of this report the term "farmer" actually indicates the woman of the household unless specifically stated otherwise.

The focus on small-scale and subsistence farm households was as much due to the force of events as design, because this is the dominant social group encountered in the rural communities covered by this study. There is a bias in the discussion, therefore, towards this group, if one's assumption is that it is considered biased to concentrate on

[6] During the course of the sweetpotato research in Uganda it was discovered that the best way to determine the involvement of men in sweetpotato production was to begin by asking them to identify sweetpotato varieties in the field. Usually at this point the man would admit defeat and call for the woman of the house to answer the questions.

the predominant social group. Nevertheless, Chapter 5 provides information on the practices of some commercial-scale producers.

3. The National Context

While Uganda is the biggest sweetpotato producer in Africa, this is not the only reason for studying postharvest aspects of the crop. Also important is the dynamism of the re-emerging economy and the potential role that sweetpotato could play in a rapidly changing society. Furthermore, undertaking postharvest research in Uganda, as well as supporting such research, is relevant to the restructuring and rehabilitation of the agricultural research system generally.

Economic Situation

Despite remarkable progress in the rehabilitation process, Uganda remains one of the poorest countries in the world. Per capita income was only US$220 at the time of the study (World Bank, 1995). The Ugandan economy and social indicators bear the mark of nearly 15 years of political turmoil and economic decline. This was a period characterized by the virtual collapse of formal economic activity, of a retreat to subsistence production from a buoyant cash crop system, and of the almost complete failure of the provision of public services or, in other cases, their *de facto* privatization (Brett, 1993).

Since 1987, the Government has been implementing an economic reform program supported by a large number of international donors. This program aims to promote prudent fiscal and monetary management, improve incentives to the private sector, institute reforms in the regulatory framework, and develop human capital through investment in education and health.

A recent World Bank (1996) report concludes the following: "Uganda's economic recovery and macro-economic stabilization have been successful, and a number of structural and institutional reforms have been initiated during the past few years. These achievements present a window of opportunity for a strong private investment response and export diversification. Otherwise Uganda remains vulnerable to commodity booms and busts."

Sweetpotato is now viewed as a cash crop as farmers start to look beyond subsistence production, as a result of the revitalization of agricultural markets. Opportunities for agro-processing that are emerging in the liberalized economy will certainly increase the demand for raw material. If there is a supply-side response to increased demand for sweetpotato, postharvest research will also be needed. Current recommendations to develop rural infrastructure to stimulate rural non-farm activities such as agro-processing may lead in turn to a sweetpotato production response by farmers.

The World Bank (1996) also suggests that although there has been a reduction in hard-core poverty in Uganda it still remains a major problem. This observation is supported by the following conclusions from the same report:

- Poverty has not yet fallen substantially in Uganda, but hard-core poverty has been reduced.
- The poor are predominately rural; the east and the north are the poorest regions.
- The urban-rural income gap has widened slightly.
- Food crops account for about 90% of total income earned from agriculture, including home consumption. This is a legacy of the retreat to subsistence that occurred when civil disruption began in 1972.
- Domestic terms of trade for cash crops have improved because of liberalization. This change has benefited the poor as well as the non-poor.
- The emerging export demand for a number of food crops has led to a prompt supply response, benefiting both the poor and the non-poor.
- Whereas production of cereals, pulses, and oil crops has increased (due to expanded area) the production of root crops has stagnated in the absence of a major boost in demand and because of inefficient technology.
- Female-headed households are not poorer than other households in terms of expenditure but are disadvantaged on several social indicators.

Therefore, in addition to the potential utilization opportunities the expanding economy presents, research on postharvest issues of sweetpotato has real relevance to poverty alleviation goals. The following points about sweetpotato are notable:

- It is an important crop in the poorest regions of the country.
- It makes a considerable contribution to the rural economy in these areas as it is widely traded.
- Improved terms of trade for food crop producers are likely to provide greater benefits to sweetpotato producers.
- Research on sweetpotato production and utilization technology may produce the demand boost and technical impetus required to reverse the stagnation of root crop production that is a major cause of poverty.
- Strengthening of sweetpotato, traditionally a women's crop, production systems provides an additional avenue of support for the rural female population.

Agricultural Research: Institutional Issues

During the period of civil unrest, Uganda's agricultural research system suffered many problems in common with other public sector services. Funds for research disappeared. Staff salaries were rarely paid, and high inflation made these earnings worthless. Some personnel left the research system to seek alternative sources of income. Some fled the country, and others disappeared. The physical infrastructure decayed rapidly in the absence of regular maintenance.

During the past decade, the Government of Uganda has undertaken an ambitious program to rehabilitate the national agricultural research system (NARS). The physical plant and facilities have to a large extent been repaired. The institutional structure of the NARS has been radically reorganized with the creation of the National Agricultural Research Organization (NARO). The goal of this restructuring has been to create a small core of well-trained and qualified staff, and provide adequate resources to undertake high quality research. The International Service for National Agricultural Research (ISNAR) assisted in planning this restructuring; financial assistance came from the World Bank.

This re-organization is on going. It is hoped that this process will help tackle some of the structural issues that in the past tended to weaken the impact of postharvest research. Particularly important is the reduction of institutional segregation and repairing weak linkages between postharvest research and commodity programs. In the case of sweetpotato, this has resulted in the relatively recent inclusion of postharvest characteristics as screening criteria in the national sweetpotato breeding program. Stronger integration of production and postharvest research would certainly be desirable.

Capacity-building and human resource development have clearly been a key activity in the NARS. Collaborative research projects with International Agricultural Research Centers (IARCs) and scholarships for overseas training have assisted in this process. In the context of postharvest and sweetpotato research, capacity-building has tended to focus on improving skills in highly specific technical fields. This has strengthened institutional capacity to undertake basic biological research.

However, these technical skills alone may not be sufficient in the more adaptive areas of research which are likely to have a more immediate impact on the economy. For example, value-added agro-processing activities have important potential for economic growth and poverty reduction in the context of the improving economic environment. To meet Ugandan conditions, research in this area (which is highly relevant to sweetpotato) requires the adaptation and contextualization of "on-the-shelf" technologies. Adaptive research of this nature needs strong social science input; and capacity-building at the doctoral level is required within the national postharvest program.

Conclusions

Uganda has made significant progress in rehabilitation of its economy. Opportunities for agro-processing, particularly of sweetpotato, have potential to contribute to the economic and poverty-alleviation aims of current governmental policy. In the on-going process of rehabilitation, reorganization and capacity-building, stronger links need to be built between postharvest and commodity program research. The NARS has significantly improved its capacity to undertake basic biological research. However, if

emerging opportunities in agro-processing are to be exploited fully, capacity-building in the social sciences needs to take place. These skills are vital in adaptive research as part of the process of exploiting "on-the-shelf" postharvest technology.

4. Sweetpotato in Ugandan Food Systems

The traditional Ugandan diet contains a large proportion of a starchy staple, such as matooke, cassava, sweetpotato or cereal (maize, sorghum, or millet), accompanied by a sauce made of beans, vegetables, fish, or meat. Preference for a particular starchy staple tends to be influenced by agro-ecological zone, ethnic group, or seasonal availability. However, in any given area, there tends to be some degree of diversity in the production and consumption of the major starchy staple (see Table 4.1). With no complete dominance by one particular staple, the strength of the current food system lies in its diversity—this is true both in the context of the food system generally and particularly in the context of the farm-level food security systems. Each crop with its own production and postharvest (particularly storage) characteristics plays a particular role as a component of the wider system.

In reviewing the postharvest constraints of sweetpotato, it is important to place the relative importance of the crop and its associated constraints within the broader context of the food, food security and postharvest systems. The rationale for this and the interrelationships of these systems has already been discussed and the various systems concepts have been described in Chapter 2. To reiterate, the key is to distinguish between sweetpotato postharvest constraints which represent a constraint in the whole system, and those constraints which are accommodated by food system components of other crops. To achieve this goal, it is useful to review some of the factors that determine the role of sweetpotato in the food systems in Uganda. The most important of these factors are agro-ecologically determined production patterns, i.e. features of the farming and cropping systems.

Agro-Ecological Zones

The importance of sweetpotato in the cropping system (and therefore the food system) is determined partly by climate and, in some cases, by soil conditions.[7] Production patterns suggest that as a result of its relative tolerance to drought, sweetpotato tends to assume a greater importance in cropping systems in the drier eastern and northern districts of the country (Table 4.1). It is in these districts where it is of greatest importance in the food system. In southwestern Uganda where rainfall is higher, crops such as matooke dominate, with sweetpotato becoming a relatively minor crop and

[7] In using secondary data aggregated on a district basis in Uganda, it is important to note that districts do not represent discreet agro-ecological zones with uniform production environments. In fact, districts are only administrative units which often show great heterogeneity of agricultural contexts, often encompassing two or more major agro-ecological zones. Nevertheless, some of the more generalized patterns of agricultural production, which a district-based approach offers, can be useful in providing an agro-geographical overview.

Table 8.3. Comparison of production costs (USh) for wheat and sweetpotato breads, made using the same sugar recipe and assuming a 50% increase in the cost of wheat flour.

	Wheat flour			Grated sweetpotato (Tanzania)			Sweetpotato flour (Tanzania)		
	Price/unit	Units	Total	Price/unit	Units	Total	Price/unit	Units	Total
Wheat flour (kg)	1,050	25.00	26,250	1,050	21.00	22,050	1,050	21.00	22,050
Sugar (kg)	820	0.80	656	820	0.80	656	820	0.80	656
Sweetpotato (kg)	-	0.00	0	150	10.50	1,575	-	0.00	0
Sweetpotato flour (kg)	-	0.00	0	-	0.00	0	500	4.20	2,100
Yeast (kg)	2,468	0.10	247	2,468	0.10	247	2,468	0.10	247
Improver (kg)	2,222	0.45	1,000	2,222	0.45	1,000	2,222	0.45	1,000
Fat (kg)	1,600	1.00	1,600	1,600	1.00	1,600	1,600	1.00	1,600
Electricity	-	-	11,375	-	-	11,375	-	-	11,375
Labor	-	-	1,610	-	-	4,062	-	-	1,610
Depreciation	-	-	124	-	-	124	-	-	124
Ground rent, licenses, etc.	-	-	22	-	-	22	-	-	22
Water services	-	-	217	-	-	217	-	-	217
Total costs	-	-	**43,101**		-	**42,928**	-	-	**41,001**
Revenue	700	70.00	49,000	700	70.00	49,000	700	70.00	49,000
Net revenue			5,899			6,072			7,999
Revenues per loaf			84			87			114
Net revenue cost ratio			0.13			0.14			0.19
Change in revenue cost ratio (%)			0			3.35			42.54

Assumptions:

Wheat flour cost: Bulk purchase, delivered from grain millers @ 35,000 USh per 50kg bag.

Sugar cost: Bulk purchase @ 41,000 USh per 50kg bag.

Yeast cost: Bulk purchase @ 80,000 USh per box of 72 450g packets.

Sweetpotato flour costs: Dry chips @ 300 USh per kg (seasonally adjusted); transport 50 USh per kg; milling 50 USh per kg; commercial mark-up 100 USh per kg; total cost 500 USh per kg.

Sweetpotato root costs: Kampala market prices 1995.

Labor costs: Monthly bill for medium-sized bakery 1.84 million USh; 80,000 loaves per month; 23 USh per loaf.

Additional labor costs: Grating sweetpotato: 2.8 person minutes per kg; washing 0.4 person minutes per kg; grating 41.5 person minutes per kg. Assuming an 8-hour day, additional labor equivalent to 0.093 person days per kg @ 2,500 USh per day = 232.5 USh per kg.

Depreciation costs: Equipment and building costs 117 million USh @ 10% p.a. equivalent to 1.7 USh per loaf.

Electricity costs: Monthly bill for medium sized bakery 1.3 million USh, equivalent to 16.25 USh per loaf.

Cost of ground rent, licenses, etc.: For medium-sized bakery, 300,000 USh per year, 0.313 USh per loaf.

Cost of water services: 250,000 per month, equivalent to 3.1 USh per loaf.

acting as a subsidiary staple in the food system.[8] In areas with altitude-modified climates which preclude the production of perennial food crops such as matooke, sweetpotato is a major component of cropping systems along with other annual staples for example, in Kabale and parts of Kabarole. In these cases sweetpotato acts as a complimentary major staple in the food system.

The comparison of production patterns based on tonnage of production (See Table 4.1) is slightly misleading as it tends to exaggerate the importance of root and tuber crops which contain 50-70% moisture (Coursey, 1982). A modified proportional ranking of crop production, also presented in Table 4.1, shows that although there are many districts where sweetpotato is in the top three starchy staples, grain and non-grain staple production is much more evenly spread.[9] Table 4.2 illustrates the way farmers ranked the abundance of starchy staple crops at needs assessment sites in the eight districts. Farmers' rankings appear to confirm that, whereas sweetpotato may be among the important staple crops at these sites, there are many other important grain and non-grain staples. The most important issue illustrated in Tables 4.1 and 4.2 is that in any given area, starchy staple production and consumption are less polarized than might at first be assumed. (The situation in Kumi and Soroti are exceptions to this and is discussed below.) Sweetpotato is generally one of a number of alternative, and often complimentary, starchy staples.

Table 4.2. Farmers' ranking of abundance (area) of starchy staple crops at case study sites.

	Crop								
	Sweet-potato	Matooke	Cassava	Millet	Sorghum	Maize	Beans	Ground -nut	Potato
Luwero	2	-	1	5	-	4	-	3	-
Mbarara	3	1	8	4	6	4	2	7	5
Iganga	2	1	3	4	8	5	6	7	-
Kabale	1	-	-	6	4	5	3	-	2
Kabarole	6	-	-	5	-	1	2	3	4
Kumi	1	-	6	4	3	7	5	2	-
Masindi	4	5	1	2	-	3	6	-	-
Soroti	1	-	7	4	3	6	5	2	-

- = Not widely grown.
Source: PRA crop abundance ranking exercises at needs assessment survey sites 1994.

[8] Actually, the regional importance of sweetpotato has increased in many areas including the northern districts due to disease problems with dominant and co-dominant staples. This issue is discussed in detail at the end of this section by illustrating the changes that have taken place in Soroti District.
[9] Unfortunately, the source for the figures used in Table 4.1 did not contain data for some of the northern and northeastern districts due to physical insecurity. In some of these districts, most notably Soroti and Kumi, the polarization of production seems particularly marked. Needs assessment case studies in these districts are discussed later in this report.

Ethnic Groups and Food Preferences

The abundance of different starchy staples described by farmers and illustrated in Table 4.2 is the result of a combination of, and interplay between, production conditions (physical environment determined by agro-ecological zone) as well as culturally determined food preferences (social environment). In the case of sweetpotato, this has a direct influence on the role and importance of the crop. A number of ethnic groups in the country recognize sweetpotato as a main food, namely the Bakiga (Kabale District); the Itesot (Soroti and Kumi districts); the Bagisu (Mbale District); and the Busoga (Iganga District) (Mwesigwa, 1995). These are also areas where sweetpotato has a production advantage over other starchy staples, particularly matooke, due to lower rainfall. In areas where the crop is culturally identified as a main food, it plays one of two roles, either as the dominant starchy staple or as one of a number of major starchy staples.

In the central and southern districts of Uganda, matooke is considered the main food and sweetpotato is seen as a poor man's crop, or as food which is resorted to in times of hunger (Ibid.).[10] No major agro-climatic constraints to sweetpotato production are present in these regions; in fact, conditions are ideal. However, in these areas conditions are also suitable for producing matooke, a crop strongly identified as the most important food in Uganda, especially in the Buganda culture (Nzita and Mbaga 1993).

Differing Roles

A combination of agro-ecological conditions and culturally determined preferences have assigned sweetpotato three distinct roles in cropping and associated food systems. The following is a description of these three distinct roles and of the districts in which they were encountered in the needs assessment survey, and the relative importance of these roles (which also pertain to districts not covered by the survey):

- Predominant staple providing the majority of dietary starch throughout the year: Soroti, Kumi, parts of Northern Luwero.
- One of a number of major complimentary staple crops consumed almost throughout the year with seasonal peaks: Kabarole, Masindi, Kabale, Iganga.
- Famine reserve staple which is only consumed in significant quantities during seasonal shortages of the dominant starchy crop, usually matooke, or when unusual pest or climatic conditions have reduced the availability of the main food: Mbarara.

In addition to the essentially consumption roles described above, sweetpotato is also an important source of cash income either as a crop strictly for sale or more commonly a

[10] During the course of the needs assessment survey, the low social status of sweetpotato was apparent from the surprise expressed by farmers and particularly district agricultural extension staff that a research program was being devoted to the crop.

source of revenue from petty trading. The latter is particularly important in the context of the rural economy in Uganda where small farmers have few options for accessing cash. The following illustrates the different food system roles played by sweetpotato and relates them to the consumption patterns observed at the needs assessment sites.

Sweetpotato as the Predominant Starchy Staple

In Kumi, Soroti, and northern Luwero districts, sweetpotato is a strongly dominant feature of consumption patterns. This is a relatively recent phenomenon as traditionally sweetpotato was a supplementary staple to cassava in these areas. Cassava was not only a major source of food, but also a major source of revenue for farmers. The emergence of African Cassava Mosaic Virus Disease (ACMVD) in Soroti District in 1986[11] drastically reduced cassava production. Farmers responded to this problem by switching to sweetpotato production, causing the crop to assume a different and much more important role in the local cropping and food system.[12]

The Soroti case study illustrates this new role for sweetpotato. The levels of production of cassava and sweetpotato have almost reversed. Between 1990 and 1993 cassava production in Soroti District declined from 16,734ha to 4,455ha, while sweetpotato rose from 6,613ha to 16,421ha in the same period (Table 4.3). The decline in production of cassava has been associated with a decline in millet (the second component in a composite flour with cassava).

Table 4.3. Production trends (ha) of the major starchy staples in Soroti District 1985-93.

Year	Crop				
	Sweetpotato	Sorghum	Maize	Cassava	Millet
1985	16,221	16,582	3,216	19,347	39,271
1986	8,679	10,261	2,002	10,337	25,317
1987	5,462	8,967	879	8,672	25,094
1988	10,150	11,181	1,263	-	26,207
1989	9,226	11,440	1,252	15,565	31,647
1990	6,613	12,378	1,278	16,734	34,812
1991	15,424	17,442	3,139	15,899	31,132
1992	19,020	16,532	2,464	3,797	15,346
1993	16, 421	11,207	2,071	4,455	12,575

Source: District Agriculture Office, Soroti.

[11] Since its emergence, ACMVD has been most devastating in the districts of northern Uganda. Although the disease front is spreading southwards through the country, its effect is most marked under conditions of environmental stress.

[12] Further details of the evolution of the food and postharvest system due to ACMVD can be found in Hall (1996).

Similarly the proportional increase in sweetpotato production has been associated with a similar trend in sorghum (the second component in a composite flour with sweetpotato).[13] These production trends continue.

The changes brought about as a response to ACMVD have had important implications for the farm-level sweetpotato postharvest system as well as for the farm-level food security system. Both Table 4.4 and Figure 4.1 display the way in which sweetpotato, in its various forms, provides most of the dietary starch consumed throughout the year. During the "hunger period" in May and June, sorghum and to a certain extent millet, cover the shortage of sweetpotato. Relying on sweetpotato as a major staple in this relatively harsh production environment where it can only be consumed fresh for 7 months of the year and is in abundance for 3-4 months has required some specific postharvest strategies—some of which represent a significant evolution of pre-ACMVD practices. The nature and constraints of these postharvest strategies are detailed in Chapter 5.

In the semi-arid northern districts where the impact of ACMVD has been most severely felt, sweetpotato is becoming of central importance, both in terms of food security and as an income source. The food consumption pattern in Soroti District is almost totally dominated by the crop (Table 4.4). In this sense, sweetpotato in this area is the key to the sustainability of rural livelihoods.

Sweetpotato as a Complimentary Major Starchy Staple

The most common role for sweetpotato is as one of a number of major staples in the cropping and food system. This scenario was encountered during the needs assessment at survey sites in Masindi, Kabarole, Kabale, and Iganga districts. The Masindi case study provides a useful illustration.

Farmers at the Masindi site ranked sweetpotato fourth in terms of abundance (area planted), but third in terms of amount consumed compared to other staples. The abundance ranking was cassava[14] first followed by millet, maize, sweetpotato, matooke, and beans. The ranking for consumption was millet first (combined with cassava flour), followed by matooke, sweetpotato, cassava (fresh) and, maize (Table 4.5). There is a distinct pattern in the importance that sweetpotato and other staples assume at different times of the year (Figure 4.2).

Farmers indicated that they eat more sweetpotato during the period when it is abundant (August - November) than grains such as maize and millet, even though these foods are also available at this time. This strategy exploits the storability of grain versus the perishability of root crops. This consumption pattern is reversed when there is a shortage of sweetpotato or cassava, and millet and other stored grains are consumed,

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[13] It should be noted that production figures during this period also showed a general decline across all crops due to physical security problems and cattle rustling.

[14] As of the time of the assessment, ACMVD had not had a serious effect on cassava at the survey site, in the south west of Masindi district.

demonstrating how farmers solve the perishability problem of sweetpotato using an integrated postharvest strategy. In this production system sweetpotato can be consumed for 11 months of the year. Therefore, in addition to using other crops to cover shortfalls in sweetpotato supply, the underlying production strategy is organized in such a way as to extend the availability of sweetpotato for as long as possible. This is achieved using a number of strategies:

- **using a menu of varieties:** selection of early and late maturing varieties, and varieties with non-simultaneous root production;
- **staggering planting:** spreading out the availability of mature roots; and
- **in ground storage and piecemeal harvesting:** sequential harvesting of mature roots.

The nature and constraints of these postharvest strategies in the context of the role of sweetpotato as a complimentary major staple are discussed in Chapter 5.

In areas where sweetpotato plays the role of a complimentary major staple, its importance lies in the fact that it is a component of an integrated cropping, food and food security system. As with other components (crops or commodities), its importance also lies in the fact that it helps underpin the wider system. As a source of revenue sweetpotato is also important, mainly through petty trading, but also through strictly commercial production in Iganga district. But it is not the most important source of revenue. In this sense sweetpotato, in these regions, plays an important role supporting the sustainability of rural livelihoods, but it is the integrated nature of cropping and food system components which is key.

Table 4.4. Food consumption patterns in Soroti District.

	Percent of annual consumption, by month[1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fresh sweetpotato	0	0	0	0	0	7	7	29	28	19	7	3
Dry sweetpotato (sliced)	7	13	25	40	8	0	0	0	0	0	2	5
Dry sweetpotato (crushed)	17	16	8	4	1	1	2	4	7	9	13	18
Millet	0	0	0	0	0	26	53	21	0	0	0	0
Food abundance	0	0	0	0	0	0	0	41	38	9	6	6
Food scarcity	0	0	0	17	15	68	0	0	0	0	0	0

[1] Rows sum to 100%.

Source: PRA exercise with farmers in Achaboi Village, Soroti District, 1994.

Figure 4.1 Food consumption patterns in Soroti case study (% of annual).

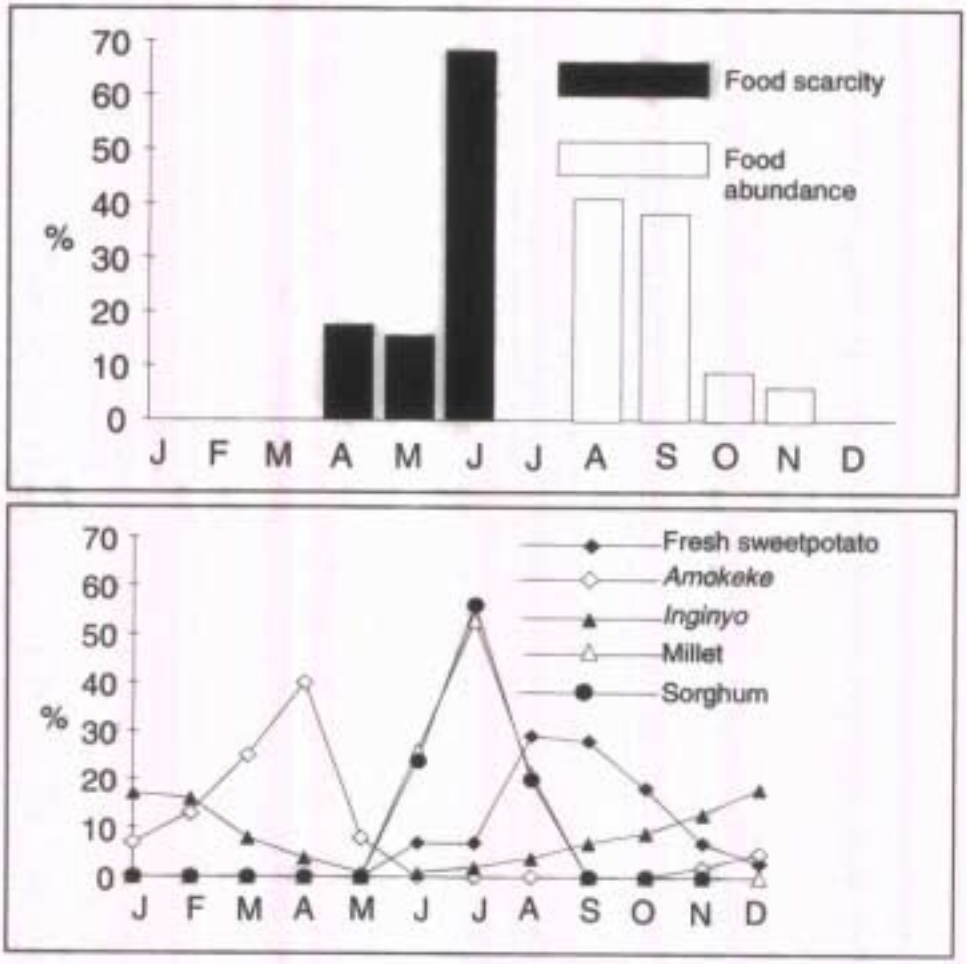


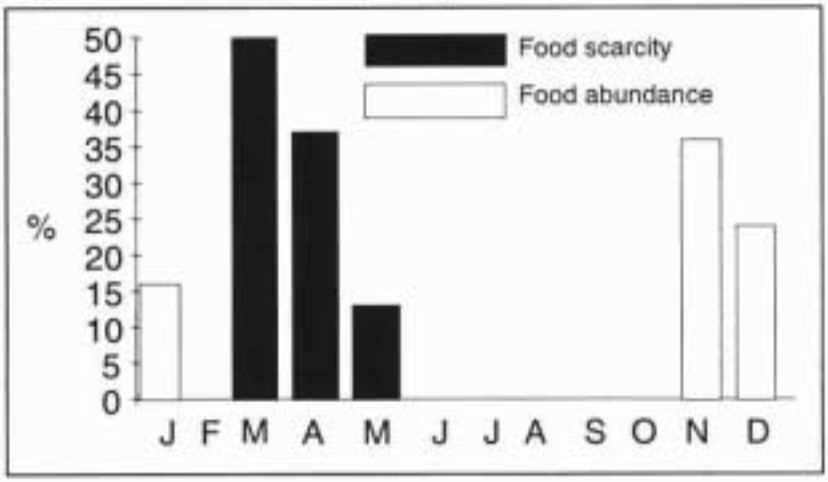
Table 4.5. Food consumption patterns in Masindi District.

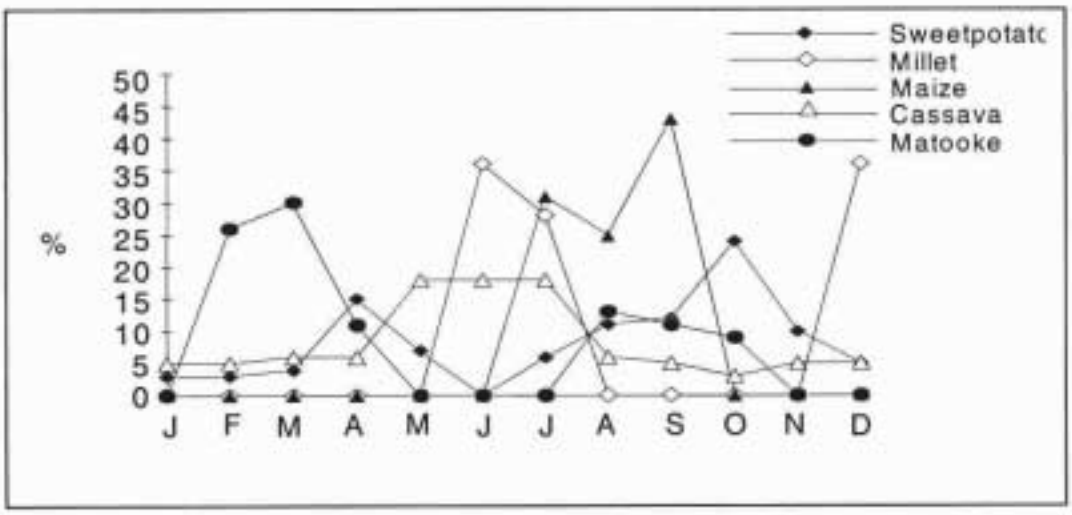
	Percent of annual consumption, by month[1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sweetpotato	3	3	4	15	7	0	6	11	12	24	10	5
Millet	0	0	0	0	0	36	28	0	0	0	0	36
Maize	0	0	0	0	0	0	32	25	43	0	0	0
Cassava	5	5	6	6	18	18	18	6	5	3	5	5
Matooke	0	26	30	11	0	0	0	13	11	9	0	0
Food abundance	16	0	0	0	0	0	0	0	0	36	24	24
Food scarcity	0	0	0	50	37	13	0	0	0	0	0	0

[1] Rows sum to 100%.

Source: PRA exercise with farmers in Byerima Village, Masindi District, 1994.

Figure 4.2 Food consumption patterns in Masindi case study (% of annual).





Sweetpotato as a Famine Reserve Staple

Sweetpotato fulfills the role of a famine reserve staple generally in those districts where matooke production and consumption dominate, particularly Bushenyi, Masaka, and Mbarara. The situation encountered in Mbarara demonstrates this role.[15] As a famine reserve staple, sweetpotato provides variety in the diet and fills gaps in the production calendar of other staples, particularly matooke (Table 4.6 and Figure 4.3). There is abundant sweetpotato in July, August, and September. In this food system, a proportion of the crop often remains in the ground. These unharvested roots should not be

[15] Although the major matooke-producing districts are now Bushenyi, Masaka, and Mbarara, anecdotal evidence suggests that this was not always so. Apparently the districts of Mukono, Mpigi, and Mubende were previously the major producers. Sweetpotato and cassava have consequently increased in importance in these districts. There is some controversy over the cause of this change; it may be due to falling soil fertility or banana nematode infection. Others suggest that it is due to a lack of farm laborers as blue-collar workers move to Kampala to seek employment (personal communication, W. Kyamuhangire, Department of Food Science and Technology, Makerere University at Kampala).

regarded as a food loss, but as a food reserve stored in the ground which, even if not consumed, have served a purpose as contingency against hunger. Areas of land where sweetpotato is grown and then stored in the ground are relatively small and, therefore, represent a small opportunity cost in terms of land, particularly when balanced against the function which the crop fulfills.

Although it is common in the literature to find sweetpotato described as a famine reserve staple (or crop) in relation to its consumption in the matooke-growing districts of the country (e.g., see Bashaasha et al., 1995), this term is rather misleading. Famine reserve would tend to imply that sweetpotato is only grown as a contingency against a crop failure or other unusual food deficit situations. This may be the case with some groups of farmers, however, farmers in Mbarara indicated that sweetpotato was consumed every year, and in considerable quantities. Most sweetpotato is consumed during May and June when the preferred staple is in limited supply.

An interesting feature of the food systems is that the period of greatest consumption, May and June, is not the period of greatest abundance, September to November. This suggests that rather than sweetpotato being a famine reserve staple, it is an integral component of the annual food security strategy and local food system. To achieve this role farmers pursue a number of cropping and postharvest strategies. These are the same as in the case of the crop playing the role of a major complimentary staple: namely, a menu of varieties, staggered planting, in-ground storage and piecemeal harvesting. The nature and constraints of these practices in the context of the role of sweetpotato as a famine reserve starchy staple are detailed in later discussion.

In the role described above, sweetpotato's importance lies in its role of underpinning food security strategies and as a minor component of an integrated food system. In this sense the crop in this area backstops the sustainability of rural livelihoods, although its importance may increase dramatically in years when the production of major food staples fail.

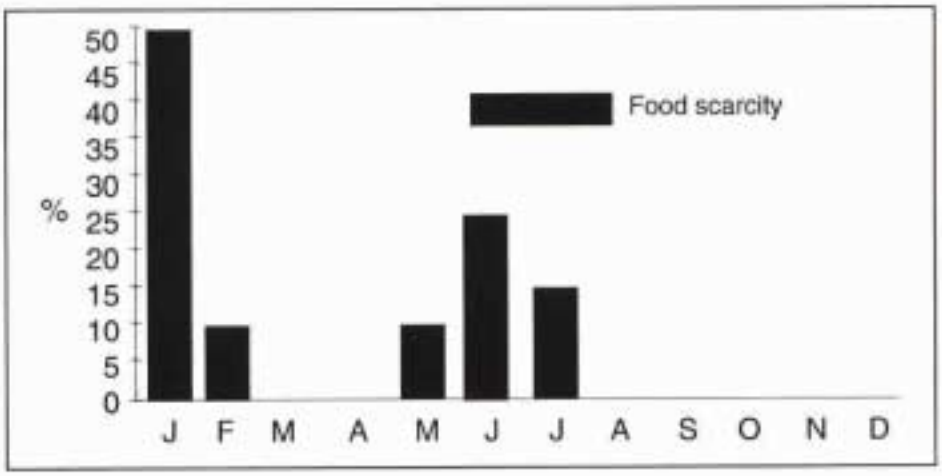
Table 4.6. Food consumption patterns in Mbarara District.

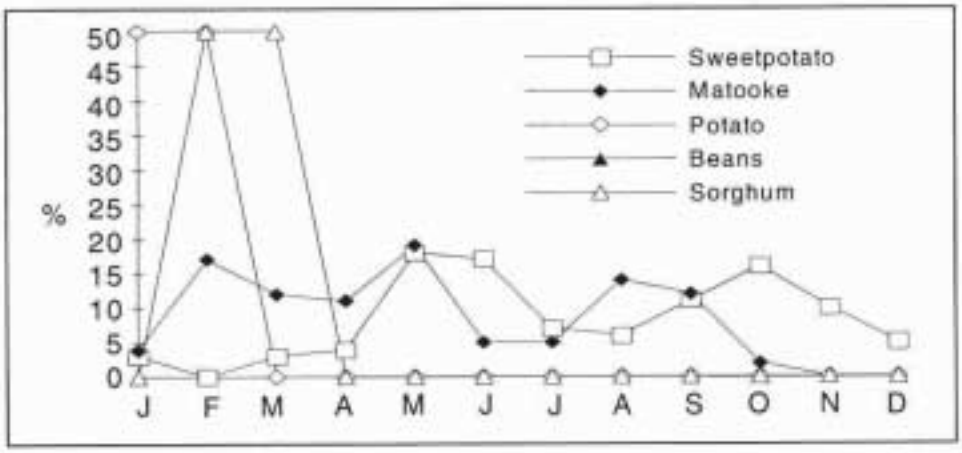
	Percent of annual consumption, by month[1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sweetpotato	3	0	3	4	18	17	7	6	11	16	10	5
Matooke	4	17	12	11	19	5	5	13	12	2	0	0
Potato	50	50	0	0	0	0	0	0	0	0	0	0
Beans	0	50	50	0	0	0	0	0	0	0	0	0
Sorghum	0	50	50	0	0	0	0	0	0	0	0	0
Food scarcity	45	8	0	0	0	9	24	14	0	0	0	0

[1] Rows sum to 100%.

Source: PRA exercise with farmers in Keizibate Village, Mbarara District, 1994.

Figure 4.3 Food consumption patterns in Mbarara case study (% of annual).





Sweetpotato as a Source of Cash Income

Sweetpotato appears to play a significant role as a source of cash income. The needs assessment survey encountered two scenarios. One consists of large-scale commercial production which locally means one or more hectares of sweetpotato grown specifically for sale. This was observed at the Soroti, Kumi, and Iganga survey sites. The other features semi-subsistence farmers cultivating the crop predominately for home consumption, but selling small amounts to raise cash for expenditures such as emergency medical treatment or school fees. In areas that relied heavily on cassava as a cash crop, e.g., Kumi District, with the disappearance of cassava because of the advent of ACMVD, the importance of sweetpotato as a cash crop has increased. A recent study (Ocoth, 1995) in Kumi District illustrates that the increased production of the crop has in turn been reflected in the emergence of sweetpotato as an important traded crop (Table 4.7). This topic is covered in greater detail in Chapter 7 which considers marketing.

Table 4.7. Farmer (n = 19) perception of sweetpotato as a food and cash crop and its importance relative to other cash crops.

Factors	Relative importance (%)
Main goal of production	
Consumption	10.3
Sale	24.1
Both	65.6
Scale of production	
Large scale > 3 acres	34.4
Small scale < 3 acres	65.6
Other food crops grown and marketed	
Groundnuts	62.1
Greengrams	37.9
Cowpeas	27.6
Cassava	20.7
Finger millet	10.3
Sorghum	6.9

Source : Ocoth, 1996.

As already discussed, in Soroti and Kumi, sweetpotato is extremely important as a source of revenue. Even petty trading of the crop in these and other areas confers a high importance to the crop due to the lack of other opportunities to access cash in the context of the local rural economy.

Summary

Ugandan food systems contain a diverse range of grain and non-grain staples which reflect agro-climatic conditions and ethnically determined food preferences. The strength of the food system in rural areas is a result of the integrated nature and complimentarity of its component food staples. Sweetpotato is often a major food staple and is of critical importance, particularly where the crop is a dominant staple or co-staple in the food system. This important role of sweetpotato, an inherently perishable crop, is supported by a number of production and postharvest strategies designed to prolong its availability throughout the year. The decline in production of cassava, a major co-staple in certain districts, however, has reduced the effectiveness of some of these strategies in the regions where the crop has assumed greatest importance. The next section examines in more detail specific postharvest systems and strategies associated with the different roles of sweetpotato, as well as their constraints.

5. Postharvest Strategies and Associated Constraints

In the strictest sense, fresh sweetpotato is not stored in Uganda. However, many farmers producing sweetpotato[16] practice a pre-harvest storage strategy that has commonly come to be known as 'in-ground storage and piecemeal harvesting' (IGSPH). This practice is part of an integrated cropping and food system in which sweetpotato planting is staggered using a mixture (menu) of varieties. The overall aim of IGSPH is to maintain a supply of sweetpotato for the longest possible period. In-ground storage is coupled with piecemeal harvesting, which is the practice of harvesting only those roots needed for immediate consumption. An essential component of this practice is that some roots are removed from individual plants while others are allowed to remain in the ground. Agro-ecological factors, particularly available soil moisture, determine the period over which the strategy can be used effectively. The practice is widespread in certain districts in Uganda (Table 5.1). Findings from the needs assessment confirmed that fresh sweetpotato was available from between 7-12 months at the various sites (Table 5.2).

The components of IGSPH are:

- **Staggered planting**: The entire area to be cultivated is not planted at the same time.
- **A menu of varieties**: Varieties having different characteristics, including maturation time, are chosen to both stagger the availability of fresh sweetpotato and provide sweetpotato with different postharvest characteristics.
- **In-ground storage**: Roots are not harvested as soon as they are mature, but remain 'stored' in the ground for up to six months.
- **Piecemeal harvesting**: Only roots needed for immediate use are harvested.

The development of IGSPH has been shaped both by characteristics inherent in the crop and by the roles that sweetpotato has assumed in food systems associated with

Table 5.1. Farmers (%) practicing in-ground storage and piecemeal harvest in selected districts in Uganda.

	District						
	Kabale	Gulu	Iganga	Mpigi	Luwero	Kabarole	Arua
Sample	52	53	49	47	50	46	49
All farmers (%)	87	100	100	91	88	96	90

Source: Bashaasha et al, 1995.

[16] This includes farmers producing sweetpotato for both home consumption and small scale trading.

Table 5.2. Number of months fresh sweetpotato can be consumed in districts covered in the needs assessment survey.

District	Months per year	Agroecological zone
Luwero	7	Dry/semi-arid rangeland
Mbarara	11	Humid/perennial cropping
Iganga	10	Humid/perennial cropping
Kabale	12	High altitude/temperate
Kabarole	12	High altitude/temperate
Kumi	8	Dry/semi-arid rangeland
Masindi	11	Humid/perennial cropping
Soroti	7	Dry/semi-arid rangeland

Source: Number of months based on information derived from PRA exercises with farmers at case study sites, 1994.

different agro-ecologies (see Chapter 4). The requirements placed on the crop in traditional[17] farming and food systems are that it must provide a supply of fresh roots over an extended period of time.

In the needs assessment survey the practice was found to be associated with all roles that the crop plays in food systems: namely predominant staple, complimentary major staple, famine reserve staple, and a source of cash to meet living expenses throughout the year.

A useful way of describing the different components of IGSPH is to use the example of the Kabarole site.

Staggered Planting

Farmers interviewed in Kabarole during the needs assessment survey said that sweetpotato planting (vegetative propagation using vine cuttings) is staggered over 7 months (see Table 5.3). Most planting takes place towards the end of the two main rainy seasons, in May-June and November. Some early planting also takes place in March, April, and October. Some continues into the dry season in December. This planting practice, in conjunction with the characteristics of the varieties chosen, allows the production and supply of mature roots of sweetpotato to be spread almost throughout the year. (This is illustrated by the sweetpotato consumption pattern shown in Table 5.3.) Staggered planting avoids harvesting a glut that is difficult to store by conventional means and is one of the components of IGSPH aimed at providing a stable supply of this important staple for as many months of the year as possible. This contrasts with cereal crops which are well suited to conventional storage methods and which are

[17] The term 'traditional' is used in the sense that it refers to practices which have not been introduced by external agents. It is acknowledged that farmers' and consumers' practices, while traditional, are not static, but evolving and changing over time.

Table 5.3. Calendar of agricultural production and consumption events in Kabarole District.[1]

	Monthly percent of annual production and consumption[2]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	1	2	11	23	13	1	0	1	11	22	12	3
Sweetpotato planting	0	0	3	7	23	15	0	0	0	3	41	8
Sweetpotato consumption[3]	2	3	3	3	3	6	5	18	31	11	9	6
Potato consumption	4	0	0	15	30	31	6	5	0	0	5	4
Bean harvest	25	0	0	0	0	0	0	0	0	0	0	75
Millet consumption	17	18	13	5	9	5	4	6	6	6	6	5
Sorghum harvest	0	0	0	0	0	0	100	0	0	0	0	0
Maize harvest	28	0	0	0	0	0	0	72	0	0	0	0

[1] Figures represent orders of magnitude and are derived from farmers' scoring.
[2] Rows sum to 100%.
[3] Sweetpotato consumption is analogous with the time of piecemeal harvest.
Source: Information derived from PRA exercise with farmers in Kigunds Village, Kabarole District, 1994.

planted and harvested during relatively short periods and consumed throughout the year.

Menu of Varieties

It was often observed during the needs assessment survey that farmers practicing IGSPH grew a large number of varieties, some as many as 10 or 12. At the study site in Kabarole District, for example, farmers were growing seven different varieties. This use of a menu of different varieties appears to be central to IGSPH in that the different varieties have varying degrees of useful characteristics, maturation time, in-ground storability, and yield. Therefore, the risk related to the failure of any one variety is reduced. Farmers' criteria for choosing particular varieties are illustrated by the complex relationship between consumption (postharvest) and production demands (see Table 5.4).

For example, of the seven varieties planted in Kabarole, Kabeebe ranked first in eating preference, but last in terms of abundance (2%). Kyebandura ranked first in floury texture, second in eating preference, but fourth in terms of abundance (12%), while Mukazi ranked first in cooking ease and was the most abundant variety. Neither of the two most abundant varieties, Mukazi (40%) and Rwanubende (24%), are preferred for eating nor are these particularly suitable for in-ground storage. However, this is offset by the fact that they mature quickly and have a high yield potential. Both Mukazi and Rwanubende are the best for providing a lot of food quickly at times when there is little else to eat. The fourth most abundant variety, Kyebandura (12%), is a late-

Table 5.4. Farmer's scoring and rankings for abundance and quality of the sweetpotato varieties they grow, Kigunds Village, Kabarole District, 1994.

	Score (%)					Ranking		
	Abundance[1]	Long lasting in the ground	Early maturing	High yielding	Rots easily in the ground	Eating preference	Floury	Easy to cook
Rwanubende	24	-	37	35	63	-	-	-
Kahungyezi	3	-	5	-	-	3	-	-
Muguma	5	-	6	-	-	-	-	-
Kareebe	2	-	5	-	-	1	-	-
Kyebandura	12	57	6	15	-	2	1	-
Yosefu	14	43	13	14	-	-	2	-
Mukazi	40	-	28	36	37	-	-	1
Total	100	100	100	100	100			

[1]Abundance refers to the amount of land devoted to a particular variety.
- = Farmers did not indicate differences between varieties.
Source: Information derived from PRA exercises with farmers in Kigunds Village, Kabarole District, 1994.

maturing variety with a moderately good yield and good in-ground storage potential. It also ranked second in eating preference. Therefore, Kyebandura is important for providing food in the drier periods of the year after the early maturing varieties have been consumed.

It is a very common feature of IGSPH to find relatively abundant varieties grown at the same time which have diametrically-opposed characteristics. This is illustrated in the Kabarole case where the four most abundant varieties include both early- and late-maturing varieties. The essence of the role of the menu of varieties is that it allows farmers to obtain good yields at times when they most need food, even though this may be offset by poor consumption characteristics, and a moderate yield from varieties with good eating qualities at times when other foods are abundant.

The abundance of both early- and late-maturing varieties in Kabarole is in fact not as pronounced as at some other study sites. Farmers in Kabarole explained that they were planting fewer late-maturing varieties, such as Kahungyezi, Kareebe, and Muguma, and that other varieties had been dropped altogether because of poor yields. Additionally, there are new food crops available at times of the year when these varieties were traditionally consumed. Therefore, these varieties are no longer important in the planting menu of sweetpotato. This change in the farming system is primarily related to the introduction of potato (sometimes, and incorrectly, called Irish potato). Potato is abundant from April to July. Previously, this was a critical period of food scarcity when roots from late-maturing sweetpotato varieties provided a substantial proportion of the food available. This change highlights the way that the menu of varieties, and therefore the IGSPH system in general, can be adapted by farmers to meet changes arising in the wider farming and food system.

Examining the menu of varieties that farmers plant highlights a constraint within the strategy. Often there appear to be inconsistencies between the proportion of land devoted to varieties with desirable qualities and those with less desirable qualities; the latter sometimes predominate. Some farmers explained that the amount planted of any given variety is often as much a result of the amount of planting material (vines for vegetative propagation) available at the beginning of the planting season, as it is to the desire to plant that variety.[18] This is particularly true in the districts found in the dry/semi-arid rangeland agro-ecological zone which is characterized by a prolonged and severe dry season.

As the menu of varieties to some extent underpins the whole IGSPH strategy, a shortage and/or lack of planting material is a serious constraint (see discussion of postharvest strategy constraints). Although this could be viewed primarily as a production problem, lack of planting material of varieties with specific postharvest characteristics is also a constraint in the postharvest system. Ultimately this threatens the viability of IGSPH as a component of rural food security strategies.

In-ground storage and piecemeal harvesting

Although staggering the planting time, coupled with a menu of varieties, is an important mechanism for providing a continuous supply of roots for consumption, it is in-ground storage and piecemeal harvesting that extends root availability the longest. Farmers producing sweetpotato use in-ground storage for either home consumption or small-scale commercial production. Farmers said that a first flush of roots matures after three to four months depending on the variety. These mature roots are harvested from the mound, thereby making room for young and new roots to develop. Roots can be harvested in this manner for an additional three months, depending on the variety. After three months, however, roots remaining in the soil tend to deteriorate. Sweetpotato varieties which exhibit non-simultaneous root production are well suited to this practice.

In the case of home consumption, harvesting is usually piecemeal; only enough is harvested for one or two meals at a time. When grown for small-scale trading, only the amount necessary for immediate sale will be harvested. Farmers indicate that the longer sweetpotato tubers remain in the ground, the greater the incidence of damage from sweetpotato weevil (*Cylas* spp.) attack and losses due to rats and monkeys, and ultimately, rot. However, there is a benefit to farmers leaving sweetpotato in the ground in the dry season when the risk of weevil attack is greatest, because some rain may fall and increase the yield. The IGSPH strategy therefore contains trade-offs in regard to yield, pest attack, and availability of stored food (or income).

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[18] It is worth noting that an analysis of farmers' planting practices indicates that the major planting period is towards the end of the rainy season. Although this is partly due to the lack of planting material at the beginning of the rains, it is also because moisture-sensitive short-duration grain crops take precedence over drought-tolerant sweetpotato. Furthermore, sweetpotato planted during the period of heaviest rains produce too much vegetative growth at the expense of root formation.

Evidence suggests that the process of piecemeal harvesting may be a form of cultural pest control for sweetpotato weevil (Smit, 1997). During piecemeal harvesting, farmers remove roots protruding from the ground which are infected or which are likely to become infected with sweetpotato weevil. Furthermore, by digging in the mound through visible cracks, farmers not only locate mature roots, but they can also remove those which have been exposed to possible weevil infection. These soil cracks, resulting from tuber growth, allow sweetpotato weevil access to tubers. This suggests that while piecemeal harvesting is primarily a method that allows sequential consumption of a "stored" crop, it may also incorporate a practice that is essentially a process of storage maintenance.[19]

The practice of IGSPH appears to have evolved in traditional farming systems in Uganda for several reasons including:

- Preferences: consumption of fresh roots is preferred in many districts of the country.
- Difficulties in conventional (postharvest) storage of fresh roots: fresh sweetpotato roots are highly perishable.
- Agronomic features: many sweetpotato varieties exhibit non-simultaneous root formation (this may be a characteristic which farmers have purposefully selected); therefore, the number of roots which can be harvested at one time may be limited.
- Food security: the need to extend the availability of food. Also, in areas where sweetpotato is used as a reserve staple, it supplements the main staple in years when this performs poorly (see the discussion of the role of sweetpotato in Chapter 3).
- Varietal preference in consumption and utilization roles: farmers plant a menu of varieties to cover the multiple uses of the crop and to guard against failure of one variety.
- Cultural control of sweetpotato weevil.
- Climatic uncertainty, particularly rainfall: farmers leave sweetpotato in the ground in areas and at times of the year when rainfall is uncertain; this allows farmer gains in yield not available if harvested earlier.

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[19] Comparison of total yields from optimal one-time harvest at 6.5 and 7.5 months after planting (MAP), with the accumulated yields from piecemeal harvesting does not show a significant difference. However, weevil damage is slightly less in piecemeal harvested roots (Smit, 1997). This suggests that whereas yield is not improved by the cultural control component of piecemeal harvesting, it plays a role in lowering root damage, a storage maintenance role. Furthermore, yield and damage statistics do not allocate sufficient importance to the value of the availability of sweetpotato over a greater period of time (food security), even if the total amount of food is the same.

Constraints to IGSPH

Despite the poor storage characteristics of sweetpotato, farmers have created an integrated cropping and postharvest system that is well adapted both to this problem and to the wider demands of their food and food security systems. The IGSPH strategy is widely used and as a result underpins much of the subsistence production and consumption of sweetpotato. Therefore, ways to strengthen current IGSPH practices in the subsistence and semi-subsistence sector merit closer consideration. This is particularly true in areas of the country where sweetpotato plays a major role in the food security system. A number of constraints are apparent in current practices. These include:

- **Availability of planting material.** The menu of varieties component of IGSPH is constrained by the availability of desirable planting material. The problem manifests itself in inconsistencies in farmers' desired and actual planting strategies. Those varieties most desired are not always the most widely available in the form of planting material at critical planting times. There is an immediate need for innovative methods for providing farmers with timely and adequate supplies of planting material of desired varieties. Rapid multiplication techniques may be one approach.

- **Identification, characterization, and development of varieties with postharvest characteristics**. Because of the overlap between production and "storage", postharvest research for the semi-subsistence subsector which uses IGSPH should focus on varietal selection and improvement of varieties with good in-ground storage and utilization characteristics. There is already great diversity in Ugandan sweetpotato germplasm. A medium-term research priority should be to identify, characterize, and catalog the varieties farmers grow and identify which attributes they value. This work should be linked with efforts to more widely disseminate indigenous planting materials to farmers.[20] This goal could be combined with efforts to provide farmers with techniques on rapid multiplication of planting material. A long-term research priority should be to develop improved varieties of sweetpotato with characteristics based on farmer selection criteria. In particular, an understanding of the physiological/biochemical basis of desired postharvest characteristics (and their heritability) should be a part of any long-term work to improve Ugandan germplasm. (See also the discussion of postharvest varietal characteristics for storage of dried slices and fresh roots for processing.)

[20] Local varieties appear to have a fairly restricted geographical distribution within Uganda.

Storage of Dried Sweetpotato

Storage of dried sweetpotato (SDS) was encountered in three of the needs assessment sites: Soroti, Kumi, and northern Luwero.[21] Storage was observed in two forms; either dried, sweetpotato slices, known as *amokeke* in Soroti and Kumi or as *kaseede* in Luwero, or as dried crushed roots, known as *inginyo* in Soroti and Kumi. Dried sweetpotato is stored in conventional granaries that are used for storing grain crops, as well as sacks. The regional distribution of this practice is not totally clear. As mentioned previously, it was encountered in three survey sites and observed during a casual farm visit in northeast Masindi District. Bashaasha et al. (1995) also indicate that the practice of drying sweetpotato is fairly widespread in Gulu (28%[n=29] of districts) and Arua (59% [n=26] of districts).

The importance, as a postharvest strategy, of SDS has grown along with the increased importance of sweetpotato in farming and food systems resulting from the decline in cassava production. Although documented information is not presently available, it is probable that this will include many of the districts in northern Uganda that have relied heavily on cassava as a starchy staple. In light of the serious constraints which have appeared in this sweetpotato postharvest strategy due to its new role as the predominant staple (see Chapter 4 and the discussion at the end of this chapter), a more detailed study of the prevalence of this practice and its attendant constraints is justified.

The Soroti case study is most useful in describing the practice of drying and storing sweetpotato, as well as the constraints associated with these strategies. In this case, consumption of fresh sweetpotato begins towards the end of June and continues to November or December, depending on the weather (see Table 4.5). Farmers use the strategies of a menu of varieties, staggered planting, and to some extent in-ground storage to extend the supply of fresh roots for up to seven months. However, these practices are constrained by climatic conditions. In particular, the period when staggered planting can take place is short, because, with the on-set of the dry season in October/November, weevil damage rapidly increases to unacceptable levels. Planting can take place only from March to May and July to September. The main period of fresh sweetpotato consumption is therefore limited to three months, with small amounts of consumption for another three to four months. (See Table 4.4 and Figure 4.1).

At the time of the needs assessment (1993-94), the virtual disappearance of cassava in this region due to ACMVD has increased the importance of sweetpotato, giving it a dominant role in the food system. (The decline in cassava production is illustrated in Table 4.3. See the accompanying discussion.) This has had important implications for the SDS associated with the new role of the crop—this is discussed in

[21] In addition, Bashaasha et al. (1995) report that the practice of short term fresh storage (a week to ten days) is common in Masindi district. The needs assessment survey did not encounter this practice at any of the other survey sites in the district visited.

detail in the subsequent chapter which addresses postharvest constraints. The almost total dominance of sweetpotato, albeit in different forms (both fresh and dried), at the site in Soroti District is demonstrated in Table 4.4.

With the onset of the dry season in November and consequent weevil infestation, uneaten or unsold sweetpotato roots are either crushed as *inginyo* or sliced to make *amokeke* and then dried. *Amokeke* is reconstituted whole as a breakfast food during the remainder of the dry season. *Inginyo* is used to make flour which is mixed with sorghum to produce *atapa*, the starchy staple eaten for main meals.

As mentioned above, sweetpotato has replaced cassava to a great extent as the source of starch and therefore flour. As a result, throughout the period when fresh sweetpotato is available, some is crushed and dried to make *inginyo* specifically for flour. Sweetpotato processing is no longer restricted to the beginning of the dry season, and the resulting product is consumed throughout the year (see Table 4.5).

Farmers indicate that *inginyo* can be stored longer than *amokeke*. The two are stored separately, either in the same granary or separate granaries. *Inginyo* can be stored for 6 months; *amokeke* for about 4-6 months. *Amokeke* becomes increasingly infested by the lesser grain borer after 4-5 months. Some farmers periodically re-dry *amokeke*; sun drying drives out storage pests. It is apparent that while this practice was satisfactory when *amokeke* consumption was supplemented by cassava in the dry season, with the increased quantities of dried sweetpotato that now must be stored, the task has become extremely difficult and time-consuming. For this reason, farmers indicate that re-drying is no longer widely practiced. Table 5.5 summarizes the changes which have taken place.

Constraints to Dry Storage

The switch from cassava to sweetpotato due to ACMVD has had important implications for sweetpotato postharvest practices. The farm-level postharvest system of sweetpotato has evolved to a significant extent to cope with this situation. Specifically, modifications to processing, consumption and storage have taken place as mentioned above (Table 5.5).[22] Nevertheless the production and postharvest systems have been stretched to the point where adequate provision for basic food security is barely met. The current system struggles to cover the food availability gap in the last months of the dry season, a period when cassava was traditionally consumed.

Since the disappearance of cassava, the infestation of dried sweetpotato in the fourth and fifth months of storage (April to June) has become critical. It was in this period that cassava would have been most heavily relied upon. Also, it is at this time that farmers now suffer the most acute food shortages because millet, sorghum, and small amounts of fresh sweetpotato are not available until June. It appears that

[22] The evolutionary changes which have taken place in the farming and food systems are discussed in Hall, 1996.

Table 5.5. Key changes in sweetpotato postharvest systems following the switch from cassava to sweetpotato as the predominant staple due to ACMVD.

Before ACMVD	After ACMVD
• Cassava used as the main source of flour mixed with millet	• Sweetpotato used as the main source of flour mixed with sorghum
• Sweetpotato flour only used in the dry season (November to March)	• Sweetpotato flour used throughout the year
• Sweetpotato only processed into *inginyo* to make flour in the dry season	• Sweetpotato processed into *inginyo* whenever fresh roots are available
• Low quantities of sweetpotato processed into *inginyo*	• High quantities of sweetpotato processed into *inginyo*
• Moderate quantities of sweetpotato processed into *amokeke*	• High quantities of sweetpotato processed into *amokeke*
• *Amokeke* stored for up to three months	• *Amokeke* stored for up to six months
• Solar drying used to control storage pests	• Solar drying more difficult due to increased volumes stored

drying and storage of sweetpotato as a food security measure is being pushed beyond the limit of its "shelf life".

Examination of dried slices of sweetpotato and discussions with farmers clearly indicated that in sliced and dried form (*amokeke*), some varieties of sweetpotato, e.g., Odepalap and Ateseke, store longer than others. However, farmers do not separate the dried slices of different varieties for storage, nor do they restrict drying and storage to the varieties that store best. This suggests that, although the short "shelf life" of dried sweetpotato is a constraint to current practices, a more fundamental issue is to understand why farmers do not exploit the storability of the varieties they have already identified.

Farmers contend that they do not separate the varieties before drying because a number of different varieties are usually grown together. This is particularly true for sweetpotato grown for home consumption. There are two reasons for this practice: 1) the shortage of planting material at the end of the dry seasons forces the farmers to plant vines of whatever varieties are available; and 2) farmers prefer to grow a mixture of varieties to take advantage of the different characteristics, such as maturation time and to guard against a yield failure of one particular variety in a particular season. Farmers indicate that it is too difficult to separate the roots of different varieties once they have been harvested. Furthermore, even if separation were possible, many households only have one granary for storing the *amokeke*. In addition, the consumption of dried slices does not lend itself to the separation of varieties. By mixing varieties, towards the end of the dry season stored food will contain at least some sound dried slices. In other words, by mixing varieties, a household's store of dried sweetpotato will not be totally infested at the most critical period of food scarcity.

Farmers indicate that the commercially grown variety Osukut (or Tanzania) has the shortest shelf life in the dried form. Despite this, it is still sliced, dried, and stored; and probably is the variety which is stored in the greatest quantities. This occurs because farmers use drying and storage as a safety net for their commercial production. If all the Osukut grown for sale cannot be sold, it is simply dried and stored. This reduces the risk to the farmer in the sense that the fresh roots can be converted to a more storable form, even if it is only for a few months. At worst, farmers will have plenty of stored food and it may even be possible to sell some of the dried surplus.

The current system of SDS represents the context in which any technical intervention to improve the system must be made. While it is clear that varieties with improved storage characteristics exist, exploitation of varietal differences cannot take place until other constraints are resolved.[23] Nevertheless, in the long term the basis of these varietal differences and heritability of storage traits should be identified and used as selection criteria in the national breeding program. In the short term, current constraints could be partially addressed by providing improved access to a range of varieties that have desired characteristics. Farmer-derived varieties with these characteristics exist and should be exploited. This would help farmers to plant varieties based on how much they anticipate they will need to dry, rather than on the amount of planting material available for any given variety. Often varieties with good storage characteristics are found in very small areas; in this case, interventions to aid dissemination would be useful. (See also Chapter 4 on the need to characterize local varieties.) Improved access to varieties would also help farmers to plant in a more systematic fashion, thereby aiding the separation of varieties at harvest.

If fresh storage were available, it would help reduce the urgency when large quantities of sweetpotato need to be harvested and dried relatively quickly at the on-set of the dry season. Drying itself is time-consuming and therefore precludes activities such as sorting roots. Fresh storage would allow some varieties to be stored and eaten fresh, and allow time to sort and dry other varieties. It would also allow unsold commercial varieties to be stored until markets became less flooded with sweetpotato. Farmers would then be able to avoid the need to dry a variety which stores poorly, e.g., Osukut, and allow farmers to take advantage of improved prices later in the dry season. Having the option of storing sweetpotato for some time before drying, effectively pushes the availability of uninfested dried sweetpotato into the months of greatest food shortage. While it is apparent that fresh storage could strengthen the postharvest system and attendant food security strategies, it is important to adaptively test fresh storage technology to identify how well it meshes with existing farming and social systems (see discussion in next chapter).

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[23] It cannot be overemphasized that farmers already fully understand and recognize the difference between varieties. Repackaging this information by postharvest researchers will not help farmers.

A constraint to varietal separation in current storage practices is the limited storage capacity of farmers' granaries; they only have one place to store dried sweetpotato. Unless this situation changes, there are limited prospects for rotating the consumption of varieties with different storage characteristics. However, if the dried sweetpotato became more valuable commercially, it might be worthwhile for the farmers to expend extra resources on the construction of additional stores. This would be contingent upon increasing levels of reliable demand for dried sweetpotato and derived processed products. With this in mind, there is a need to undertake research that would monitor the price of dried sweetpotato slices and flour in comparison to competing products in the markets in areas that produce dried sweetpotato during the dry season. The comparative advantage of dried sweetpotato as a food source could thereby be assessed which would help determine if research on product development is justified (see discussion in Chapter 8).

Summary

This review of postharvest strategies has suggested that traditional practices with respect to sweetpotato are sophisticated and have historically been sufficient to support the crop in its role in the food system. The evolution of these strategies has been directed by the nature of the crop and the role it has assumed, as well as the nature of farming systems in which it is produced. In the most widespread postharvest strategy, in-ground storage and piecemeal harvesting (IGSPH), some scope exists for strengthening current practices by interventions aimed at improving farmers' access to planting material. This could be linked to general varietal improvement programs.

In the case of dried sweetpotato storage (SDS), this once adequately functioning traditional practice has been forced to assume a role with which it cannot satisfactorily cope. The sweetpotato postharvest system, and the closely associated local food security system, would benefit from strengthening on all fronts. Improved access to planting material; the introduction of fresh roots storage technology; and the introduction of low cost, non-chemical methods of storage pest control. In addition, basic research in the long term is required to identify the physiochemical basis and heritability of storage and other postharvest criteria. This needs to be incorporated in the national sweetpotato breeding program.

The following chapter now examines the viability of introducing low-cost technology for the storage of fresh sweetpotato in rural areas.

6. Technology for Storage of Fresh Roots

The previous chapters have described the features of sweetpotato food systems and the constraints which they face. Particular emphasis has been placed on problems arising from utilization of the crop in districts where cassava once served as a co-staple, but where it has virtually disappeared because of ACMVD. This chapter reviews the feasibility of using low-cost storage technology to store fresh sweetpotato, a measure that would strengthen the postharvest system while it evolves to cope with the increasing importance of sweetpotato in the food system. The following discussion covers both technological feasibility testing using on-station trials, and testing for both technological and socio-economic feasibility by on-farm adaptive trials (to check for appropriateness to the food/social system). The section begins by briefly reiterating the rationale for advocating this type of technology.

Need for Storage of Fresh Sweetpotato Roots

Sweetpotato farmers in Soroti, Kumi, and northern Luwero districts interviewed during the needs assessment survey indicated that storing fresh sweetpotato would address a need in the current food system. The three survey sites are characterized by the following features:

- sweetpotato has become the major starchy staple because of the decline in cassava production;
- to some extent, sweetpotato is used as a cash crop;
- the climate is characterized by a severe and prolonged dry season;
- sweetpotato is traditionally dried for storage during the dry season; and
- consumers prefer fresh roots.

In these areas, it is traditional to chip and dry sweetpotato allowing storage for up to three months. To fit the food system, however, this practice relied on the availability of fresh cassava to provide food beyond the three months towards the end of the dry season. Dried sweetpotato has become more important with the disappearance of cassava, and is needed to provide the major source of food for up to six months during the dry season rather than the traditional three months. The needs assessment found that during this additional storage period (months 4 to 6) insect infestation of dried sweetpotato reaches unacceptable levels.

To reduce constraints in the current system, fresh storage has been considered as an option for prolonging the period when fresh roots are available. This option could provide an opportunity for subsistence farmers to dry sweetpotato later in the dry

season; thereby lessening this constraint which arises from the short shelf life of dry sweetpotato (Hall, forthcoming).

Storing fresh sweetpotato could also provide an opportunity for farmers to stagger sales of the crop and allow them to benefit from higher market prices later in the season. Farmers said that the price of sweetpotato can rise from USh 4,500 per bag at the onset of the dry season to USh 15,000 after three months.

On-the-Shelf Storage Technology

A literature survey confirmed the existence of sweetpotato storage technology (Devereau, 1994). This review indicated that farmers store sweetpotato in a number of tropical countries where it is a major crop. Although researchers produced mixed results in their attempts to replicate some of the storage methods, those used in Malawi (Woolfe, 1992) and Papua New Guinea (Keleney, 1965; Aldous, 1976) were the most promising. It was also encouraging that these were routinely being practiced under climatic conditions similar to those in Uganda.

Three types of storage structures were featured: covered underground pits; covered aboveground mounds or "clamps"; and closed wooden boxes kept indoors. Before any of these storage technologies could be tested by farmers in the appropriate parts of Uganda, a number of technical questions needed to be answered: precise details of the technology were not clear, particularly ventilation levels in the storage structures and pre-storage treatment of the roots with wood ash. It was also not known if sweetpotatoes would store satisfactorily in the temperature and humidity regime of Uganda. The most crucial potential constraint was whether or not sweetpotato varieties common in Uganda would store well.

On-Station Trials - Phase One

Before attempting to test the technology with farmers, it was first necessary to ascertain the extent to which the storage techniques were technically appropriate to Ugandan conditions. To this end, an on-station trail was conducted in April 1994, at Kawanda Agricultural Research Station near Kampala. Approximately 100 kg of the variety New Kawoogo were stored in pits, clamps, and indoor boxes. Trials were replicated with and without ventilation and wood ash treatments.[24]

After eight weeks the roots were assessed for weight loss and consumer acceptability. Results showed that pit and clamp storage without wood ash treatments were the most successful with weight losses of approximately 4 % (Devereau, 1994).

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[24] The literature indicated that "curing" sweetpotato aids storage. No purposeful curing was undertaken in the storage trials described; however, before storage took place, curing undoubtedly occurred in the ambient conditions of temperature and humidity.

Technology Targeting

The need for fresh sweetpotato storage in Soroti District provided a geographic focus for the technology, as well as providing information about the characteristics and preferences of targeted beneficiaries. This was important because it provided an indication of the physical and social parameters under which the technology would need to perform.

Therefore, the next phase tested the technology under the prevailing climatic conditions in the target area, as well as its adaptability to the farming and food systems within which farmers were operating. The approach adopted consisted of parallel on-station trials and on-farm adaptive testing. This approach was followed because the period when storage was needed was very season specific, from November/December to April/May; therefore, trials and testing could only take place once per year.

In addition, although some technical verification was still needed, researchers felt that the technology was sufficiently robust to begin adaptive farmer testing without waiting a full year. Furthermore, it was felt that farmer input as early as possible would alert researchers to any major, unforeseen constraints to the eventual adoption of the technology.

Trials were conducted at Serere Agricultural Research Institute, a site 25 miles from Soroti Town. Farmers living near Soroti who had originally been involved in the needs assessment undertook the adaptive testing. Work began in November 1994, a time immediately prior to the on-set of the dry season when sweetpotato is abundant.

Unanswered Questions from Initial On-Station Trials

The two components of the second phase were linked, but had rather different objectives. On-station trials were undertaken to measure storage conditions under the prevailing climatic conditions and systematically test storage characteristics of sweetpotato varieties commonly grown in Soroti District. The on-farm work, in addition to testing the technical success of fresh storage, essentially addressed social and economic questions associated with the use of the technology in the farm context. The on-farm work also sought to use farmer input that would appropriately modify the technology to meet local conditions. On-station trials included both a broad and a specific objective.

Broad objective. To undertake a technical evaluation of the effectiveness of pit and clamp sweetpotato storage technology under the climatic conditions prevailing in the area where the technology was to be targeted.

Specific objective. To measure storage losses in four local sweetpotato varieties using pit and clamp stores, and to determine the feasible storage period. (Three months was predicted to be the amount of time farmers would need to store sweetpotato if it were to be a useful technology.) Specific objectives of the on-farm testing were:

- To appropriately adapt, in collaboration with farmers, the storage technology developed on-station to suit the resources and aspirations of target beneficiaries.
- To evaluate the performance of pit and clamp storage technology in the climatic and physical conditions experienced by target beneficiaries.
- To monitor the experiences of farmers to judge the acceptability of the technology.
- To undertake "cost benefit" type analyses of the technology to determine the impact of the technology on both food security and farm income.
- To test the underlying assumption that the storage technology would allow farmers to take advantage of the dramatic price increases which take place during the dry season (including the collect of relevant market prices throughout the course of the trial in the Soroti area).

An implicit objective of the on-farm work was to critically assess the process by which technology is adaptively tested and transferred to farmers.

On-Station Trials - Phase 2

On-station trials tested the storability of four local sweetpotato varieties: Osukut (or Tanzania), Ateseke, Odopelap, and Ongada. These varieties were chosen because the needs assessment survey found them to be the most abundant varieties in Soroti. Approximately 100 kg of each variety was stored in both pit and clamp stores. The trial ran from 13-14 November 1994 to 8 March 1995 (16 weeks and 3 days) at Serere Agricultural Research Station. The results after four months of storage indicated that:

- weight loss ranged from 17.5 % (Ateseke) to 31.9 % (Osukut);
- for all varieties, pit stores produced lower losses than the clamp stores (at 0.010 confidence limits);
- clamp stores showed a greater tendency to produce sprouts and this appeared to be associated with increased weevil attacks; and
- pit stored Ateseke experienced less rot than the other three varieties (at 0.010 confidence limits).

Trial results concluded that the most effective combination was the variety Ateseke stored in a pit (Devereau, 1995).

On-Farm Adaptive Testing

On-farm testing was conducted in the communities in Soroti District where the needs assessment survey was undertaken. The on-farm protocol was to convene a group meeting of community farmers, and ask them to choose individual farmers to try out the

technology. A minimum amount of information was given to the farmers about how to construct the storage facilities. They were told the pits and clamps needed to be:

- sheltered from the sun and the rain;
- protected from flooding in the event of heavy rain;
- lined with dry grass and sealed with soil; and
- roots to be stored needed to be graded to remove those which were damaged or infested.

This was explained to farmers in such a way that the emphasis was placed on the storage conditions which needed to be achieved, rather than simply on providing a 'recipe' which had to be followed; farmers decided:

- which sweetpotato varieties to choose for storage;
- how much to store;
- how to construct the storage structures;
- who was to build the structures;
- which materials to use in construction;
- where to place the stores;
- how long to store the sweetpotatoes; and
- what to use them for after storage.

The aim of this approach was to create a set of conditions in which farmers were able to contextualize the technology to their particular social and physical environment rather than handing them a blueprint of how sweetpotatoes should be stored. The emphasis of this on-farm work was to create a situation in which farmers felt that the stores were their responsibility and that they could undertake modifications as they wished.[25] This was an attempt to move away from the common model of on-farm work in Uganda in which farmers were reluctant to participate in experiments that scientists undertake in their villages.

Farmer Selection

The initial research assumption was that the scale of the technology was most appropriate for individual household use. As described above, community members, (already well known to researchers), were asked to select their own farmers to test the

[25] In order to reduce the risk to farmers of participating in the test, researchers in effect bought the sweetpotatoes from the farmers and then gave them back to them to store. It was emphasized to farmers that the sweetpotatoes belonged to them and that they could do anything with them at any time they wished. In this way, it was hoped that it was in their interests to become actively involved in the testing of the technology.

technology. They selected farmers who were widely known, popular members of the community. Although selected farmers were not from the poorest group in the community, they were representative of the majority of farmers.

Following farmer selection, one of the farmers became a "node" for a group of farmers who stored their sweetpotatoes together. Other farmers formed groups that assisted with the construction of the stores. In this way, up to 50 adult community members were involved in the on-farm trials, either directly or indirectly.

Adaptation of Storage Design

Selected farmers, plus their associates, at the four storage sites chose to construct both pit and clamp stores because they wanted to test which was the best. Before actual construction of the stores could take place, farmers needed help in their discussions about many of the aspects of the storage trial they were going to undertake. Choice of variety and amount to be stored (as this would determine the size of the stores) were important issues. Farmers chose two varieties, Osukut and Ateseke. Farmers said that in addition to these varieties being abundant and popular, they both rotted easily, Osukut in the ground and Ateseke after it had been harvested. The logic of this choice was that they wanted to improve the storage potential of the varieties that stored the poorest. Osukut is also the main cash crop variety.

Of the four storage sites, two choose a design which very closely resembled local architecture, round pits with conical thatched roofs for both pits and clamps. The remaining two sites chose a design for both pits and clamps which closely resembled that used on the research station—square pits with an oblong "pitched" roof. Both designs used local methods of construction and materials: wood and grass thatch, bark, and banana fibers for lashings and fixings. None of the storage structures contained any plastic or metal components. The characteristics of the stores are summarized in Table 6.1.

Selected farmers and the groups which had formed around them built the structures. The workers shared the tasks of digging the pit and building the roofs. The groups estimated that if they had hired somebody to construct the stores and provide all the construction materials it would have cost them USh 20,000. Based on experience with the roofs of their homes, the workers thought that thatched roofs on the stores would last about two years without re-thatching and the wooden framework could last more than five years. The experience of one of the farmers is described in Box 1.

Farmers' Reactions

On-farm testing quickly created a great deal of interest among community farmers. Not only were they surprised to hear about researchers working on sweetpotato, but were even more amazed to learn about suggestions that sweetpotato, a crop which "rots easily", could be stored for up to three months. After the initial process of establishing

Table 6.1. Summary of storage methods tested by four farmers.

	Type of store	Design of store	Variety stored	Source of sweetpotatoes	Amount stored (bags)
Farmer 1	pit	conical	Ateseke	bought from friends, some from own field	3
	clamp	conical	Ateseke	bought from friends, some from own field	2.5
Farmer 2	pit	conical	Osukut	own	2.5
	clamp	conical	Osukut	own	2.5
Farmer 3	pit	square	Osukut	own	4
	clamp	square	Osukut	own	3
Farmer 4	pit	square	Ateseke	bought from friends	4
	clamp	square	Ateseke	bought from friends	3

the stores, researchers visited participating farmers every two weeks to monitor their activities and gauge their reactions (see Table 6.2).

After seven weeks, the farmers began to open the stores to examine stored sweetpotato. Their initial findings were not hopeful. Ateseke stored in pits had completely rotted. This was the opposite of results from the on-station trials (see later discussion).

One of the farmers storing Osukut (the main cash crop variety) tried to sell some of the stored sweetpotatoes after about eight weeks. He found that although the crop had stored very well he was unable to sell the sweetpotato. This was because the sweetpotato did not have the pristine, "just-from-the-garden look," which buyers use to judge freshness. Also, the price of sweetpotato was unusual during the season that the trial was held. The rain that normally stops in November continued intermittently through the entire dry season. As a result, fresh sweetpotato was available for most of the dry season; and although prices rose, the price did not reach the usual levels (see Figure 6.1).

As the storage period increased, farmers began to remove small numbers of roots. At first they used these to test for taste. Later, roots were removed to provide a rare meal of fresh sweetpotato for their family. Farmers indicated that the stored roots were somewhat sweeter than they would have been if they had just been harvested. This seemed to be an attractive attribute, particularly to children.

Box 1. Cost of store construction.

Mr. E. has a 3-acre farm on which he grows mainly sweetpotatoes and sorghum. Mr. E. is well liked by his fellow farmers and was chosen by them to test the technology.

Mr. E. and his friends constructed a pit store which could hold 3 bags of sweetpotatoes and a clamp store which could hold 2.5 bags. The pit which he and his friends constructed was 140 cm deep by 90 cm wide, round and covered by a conical thatched roof. A similar conical thatched roof was constructed to cover the clamp.

Mr. E. indicated that it took him and his six friends one day to dig the pit. The grass he used for lining the pit and covering the clamp was collected in about half a day from public places. The roof was constructed by eight of his friends in about six hours. He used poles for the roof from an agongo tree which is on his personal property. The flexible sticks for the roof came from the akeroi shrub and the fibers for tying came from the abira tree. Both of these two species are swamp plants and Mr. E. collects them from his own personal area of swamp. The grass for thatching the roofs was collected from public places.

Mr. E. indicated that if he had needed to pay for the materials for the roof it would have cost USh 6,000, in addition the labor for construction would have been a further USh 6,000. Actually, his friends helped him because some of their sweetpotatoes were going to be put in Mr. E.'s store. Mr. E. also had to buy local beer for all the people who had helped him.

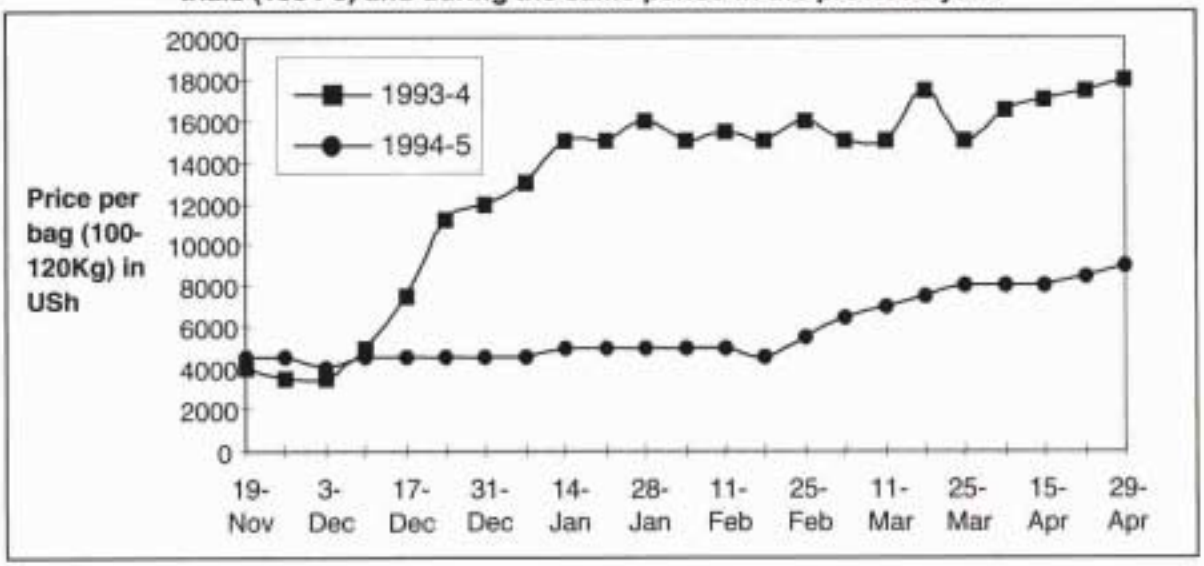
Ateseke was stored for up to 19 weeks and Osukut for 18 weeks; both in clamps. Roots were stored in pits for slightly less time than in clamps. This depended on which of the two store types farmers decided to empty first, rather than on which was the better method. Farmers indicated that they preferred the clamp storage method because clamps were much easier to construct than digging a pit. Clamp stores, however, were more difficult to seal with dry soil.

As the period that farmers were successfully storing the sweetpotatoes increased, so did the interest of other members of the community who had not been directly involved in the work. One of the traditional leaders of the area, after witnessing the technology, constructed his own store and kept sweetpotatoes for two months. When the farmers eventually decided that the potatoes should be removed from the stores, the sweetpotatoes which could not be consumed at once were sliced and dried for later consumption.

Table 6.2. Storage results of different methods tested by four farmers.

	Type of store	Design of store	Variety stored	Storage period (weeks)	End use	Comments
Farmer 1	pit	conical	Ateseke	8	discarded	Inspection of the sweetpotatoes revealed that they had started to rot.
	clamp	conical	Ateseke	19	fresh and dried	Consumed fresh piecemeal from week 12. Remaining roots dried at the end of week 19 for *amokeke*.
Farmer 2	pit	conical	Osukut	15	dried	Of 802 roots, found 707 good, 45 with some dry rot, and 52 unusable.
	clamp	conical	Osukut	18	fresh and dried	Consumed fresh during week 18, remaining roots dried for *amokeke*.
Farmer 3	pit	square	Osukut	13	fresh and dried	Tried to sell, but could not as roots did not look freshly harvested.
	clamp	square	Osukut	16	fresh and dried	Consumed fresh up to week 16, remaining roots dried.
Farmer 4	pit	square	Ateseke	7	discarded	Inspection of the roots revealed that they had started to rot.
	clamp	square	Ateseke	16	fresh and dried	Consumed fresh up to week 16, remaining roots dried.

Figure 6.1 Comparison of sweetpotato prices in the local market during the on-farm trials (1994-5) and during the same period in the previous year.



Source: Data collected from market traders in Soroti during the 1994-5. 1993-4 is recall data collected from traders during the 1994-5 survey.

To summarize, farmers found that:

- Clamps are more convenient to construct, but pits are also useful.
- Ateseke should only be stored in clamps, but Osukut could be stored in either pit or clamp.
- Stored roots are difficult to sell. (The situation may be different in years of acute shortage.)
- Fresh roots can be consumed "piecemeal" from the stores throughout the storage period which can last for up to 19 weeks.
- Sweetpotatoes become sweeter after storage.
- At the end of the storage period, fresh sweetpotato roots can be sliced, dried, and stored for an additional period.
- With the exception of Ateseke stored in pits, losses due to rotting in storage were very low.

The Cost of Food Security

As discussed earlier, the farmers undertook the construction of structures themselves. However, for the sake of convenient analysis, USh 17,500 (US$ 17) can be used as the cost of construction—an average of farmer's estimates of between USh 15-20,000 (US$ 15-20). This amount, discounted over the two years that the structures were anticipated to last, suggests a cost per year of USh 8,750. An additional cost is incurred by grading the harvested sweetpotato, although this would probably have been done anyway for roots harvested for sale. The structures could store approximately 6 bags of sweetpotatoes, equivalent to approximately 600 kg. This suggests that the cost of storing the sweetpotato was approximately USh 15 per kg (US$0.015).

Although there was clearly a problem in selling the stored roots during the trial period, in a season with greater scarcity stored roots would probably have sold, but at a price discount when compared to just-harvested roots. For the technology to break even, roots stored when the price was USh 4,500 a bag would have to be able to sell at USh 6,000. This is conceivable given that prices frequently go up to USh 15,000 in the dry season in the area of the study.

The value of the technology for food security is more difficult to judge quantitatively. One way to do this is to estimate the value of the stored roots in terms of how long it could feed an average family. With a daily consumption rate of 10 kg,[26] an average rural family could survive on the 600 kg of stored roots for 60 days, about two months. Using

[26] This assumes a family of three adults and four children, the adults consuming 2 kg per day and children consuming 1 kg per day (Mwesigwa, 1995).

the estimates of the cost for the construction of the stores, this suggests that food security can be achieved for USh 150 (US$ 0.15) day.

In reality, the value of the storage technology in terms of food security depends on farmers' perceptions of the value of access to food in any given season. It is also modified by farmers' recent experiences in years of food shortage; the more recent the greater the perception of the value of food security measures. The ultimate test of the value of this storage technology as a food security measure will be farmers' willingness to adopt and practice it without any external impetus from researchers.

Contradictions between On-station and On-farm Work

There was a contradiction in the results from the on-station work at Serere Agricultural Research Station and on-farm work undertaken in Soroti District. In the former, Ateseke was found to be the best variety for storage in pits, whereas in on-farm trials this combination lead to total loss of stored sweetpotato. The reasons behind this difference are less important than the lesson than can be learned from it. This experience certainly suggests that on-station work at best can only give a rough approximation of the conditions encountered by farmers. In this case, it is likely that farmers were so rigorous with their sealing of the pit stores that they created conditions which promoted anaerobic fermentation. There was certainly a smell of this when the pits were opened. The construction of the on-station pits (and clamps) inadvertently allowed them to be quite well ventilated. Why these anaerobic conditions adversely affected Ateseke more than Osukut is not clear.

The most important result of this research is that farmers' efforts to test the technology were facilitated and they were allowed to see which of their chosen varieties would store best, and in which storage design. The lesson for further technology development work on sweetpotato storage methods is that it is much more useful to provide farmers with storage options to test in their own locations rather than trying to design generic technologies from imprecise empirical evidence drawn from on-station trials. The ultimate test of this type of technology is if it works, in the broadest sense of the word, for the farmer, and not if it can demonstrate a statistically significant difference from one treatment to another.

At the same time the value of on-station work should not be underestimated. The phase one on-station work provided sufficient confidence in the technology for it to be considered worthwhile for farmer testing.

The Next Phase

The on-farm work described here is very much in the pilot phase. However, it has demonstrated that not only can sweetpotato be stored for up to three months in the dry season in Soroti District, but, more importantly, it is useful activity for the farmers. While the technology did not serve as a mechanism to allow farmers to achieve direct

economic benefits from selling stored sweetpotato for higher prices, it greatly improved their food security during the critical period towards the end of the dry season.

This technology is low-cost and fills a need within the food system. With the continuing decline in cassava production in the semi-arid zones of Uganda, this technology has the potential to provide a valuable aid to food security in the small-scale farming sector. Accordingly, dissemination should be seen as a priority food security intervention in these districts.

The lessons from the work carried out suggest that dissemination is best undertaken by facilitating farmers to test the technology in their own environments. This can then be used as a mechanism to demonstrate the technology to a wider group of farmers. On-station demonstrations would be both inaccessible to farmers and likely to be unrepresentative of their actual conditions. Facilitating farmers to undertake testing is done best in as non-prescriptive a manner as possible: options should be provided rather than a fixed recipe. (Technical details are described in an extension guide produced by NRI/NARO.)

The results of this work indicate that some varieties have better storage characteristics than others. This needs to be recognized by the national crop improvement program in Uganda. The breeding and improvement program require technical backstopping strategies to conduct research aimed at understanding the physiological and physiochemical basis for differences in the storability of sweetpotatoes, a potentially critical postharvest characteristic. Early stages of this work have already begun (see Rees and Westby, 1998).

7. Marketing

An in-depth sweetpotato marketing study was beyond the scope of this research. The following brief examination provides some useful insights into farm-level marketing issues. It also raises some questions about commonly held perceptions of the sweetpotato marketing system in Uganda that warrant further study.[27]

With the exception of the needs assessment sites in Soroti and Kumi, and to some extent in Iganga District, farmers who participated in this study were not practicing large-scale, commercial cultivation of sweetpotato.[28] Rather, activities associated with sweetpotato were restricted to petty trading. Farmers in the non-commercial sites often described sweetpotato marketing as difficult. One reason is that these production areas were often too far from the major urban markets for middlemen to travel to them to buy sweetpotatoes. Farmers also said that the internal market was weak. For example, in Kabarole, where most farmers had some sweetpotato all year, few people were willing to buy it.

Farmers at the Mbarara site said that despite sweetpotato's high potential, limited effective demand makes marketing of the crop nearly impossible. Furthermore, they indicated that the crop has no comparative advantage over others they grow as cash crops; "why grow sweetpotato for sale when beans can be grown which have a good market?" was a frequent comment. Exceptions were individual larger farmers who were able to secure an agreement to supply a local institution, such as a school or a prison, on a regular basis. Therefore, it would appear that despite sweetpotato's agronomic advantages, it is often viewed as a famine reserve or home consumption crop because: 1) local market demand is relatively limited, and 2) there is insufficient market pull from major consumption areas such as Kampala.

A similar phenomenon was witnessed in Kabale where potatoes, which have a strong market with buyers from as far away as Kampala, are replacing sweetpotato.

The potential for storing the crop to capture higher prices is limited in many areas, even in periods of high supply, because fresh sweetpotatoes are available most of the year. Stored sweetpotatoes would therefore have to compete with fresh roots from the field. The exception is in Soroti, Kumi, and Northern Luwero where, as discussed in Chapter 4, there is a seasonal peak and then a period when the crop is almost entirely absent.[29] In this case, storage of fresh sweetpotato would appear to offer the potential for improving household food security, as already discussed, as well as the potential for "playing" the market as local prices rise. For example, in Soroti prices can rise from

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[27] A sweetpotato marketing study was carried out by Fowler and Stabrawa in 1993 that recommended the need for more in depth studies into specific marketing issues.

[28] However, this should not be taken to imply that commercial sweetpotato producers are not found outside these three districts.

[29] However, sweetpotato grown in swamps can be found for sale during the dry season in these districts.

USh 4,000 /bag in November to USh 15,000 /bag in March. It is worth bearing in mind, however, that regional supply and price fluctuations for sweetpotato do not always reflect the situation in Kampala, the main market, which receives supplies from diverse sources. In other words, storing fresh sweetpotatoes in any one district in the hope of achieving improved prices in the Kampala market may be in vain, because like the other major urban markets it can readily switch to cheaper sources of supply.

The situation in the Iganga district studied also differed slightly. In this case, sweetpotato was grown for medium-scale trading. It was produced in a seasonal rotation with maize. Although farmers experienced some difficulties in selling the crop, storage was not an option because they used the cash raised from the sale of sweetpotato to pay for land cultivation for the following maize crop. In other words, storing sweetpotato and waiting for higher prices would involve a high opportunity cost in terms of the farmer's ability to cultivate the maize crop. This is particularly pertinent as rural credit facilities are almost totally absent in the area.

From the farmer's perspective, the underlying problem with sweetpotato marketing appears to be the limited demand for the crop, at least in fresh form. In most cases, storing peak season surpluses would not help producers because of the nature of the sources of supply to major urban markets. However, storage would be useful in some areas (Soroti, Kumi, and Luwero) where there is a marked local food shortage in the dry season. The solution to sweetpotato marketing problems, other than substitution for a different crop, appears to be in exploring options to exploit alternative markets for sweetpotato in fresh form.

Dubious Notions of Sweetpotato Marketing

The needs assessment identified some questionable prevailing perceptions regarding sweetpotato marketing on the following issues:

1. Unfair pricing by middlemen at the expense of the farmer (risk factor pricing).
2. Poor handling due to lack of knowledge of better practices.
3. High physical losses in the marketing chain.

Exorbitant marketing margins

One of the notable features of the sweetpotato marketing system is that an initial examination suggests low farm-gate prices and comparatively high prices in urban markets. For example, farm-gate prices in Soroti District in November 1994 were USh 4,000 /bag (about USh 33-40 /kg) compared with a consumer price in Kampala of USh 150 /kg (USh 12,000-18,000/bag). This large marketing margin is misleading in that it often prompts casual observers, including researchers, to conclude that middlemen are

making disproportionately large profits at the expense of both farmers and urban consumers.[30]

Two observations are in order here. Firstly, in a marketing system where there is little or no restriction on the entry of new agents, it would appear illogical to assume that profit margins—even if they were unusually high on a momentary basis—could remain so high for long without attracting new entrants. Secondly, interviews with traders and middlemen in Kampala's city markets (part of a sister study examining the demand for sweetpotato processed products) suggest that despite low farm-gate prices and relatively high consumer prices, traders' profits have been squeezed by high transport costs and district revenue authority taxes and market dues.[31] The larger scale middlemen, who generally hire 10-ton lorries, complained that the cost of this type of hire had risen dramatically due to increased activities by emergency relief agencies in the country hiring transport for supplying relief to Rwanda and Sudan.

Box 2 presents a case study of a typical large-scale sweetpotato middleman. The illustration of marketing revenues in the example presented in Table 7.1 shows that the net revenue of this particular trader was only USh 250 per bag, a net profit of 5% of the farm-gate price. The case of a medium-scale trader is shown in Box 3; and marketing margins summarized in Table 7.2.

Table 7.1. Revenues of a middleman transporting 100 bags of sweetpotato from Kumi District to Kampala city markets.

Item	Cost per bag	Total
Costs		
Sweetpotato	5,000	500,000
Loading truck	100	10,000
Transport[1]	5,000	500,000
Local taxes	100	10,000
Weigh-bridge fee	100	10,000
Unload truck	100	10,000
Market fees	300	30,000
Traffic police (one off payment)		5,000
Total costs	**10,700**	**1,075,000**
Revenue[2]		
Sale of sweetpotatoes	11,000	1,100,000
Net revenue		**25,000**
Net revenue per bag		**250**

[1] Includes hire of lorry, fuel, and 'turn boy' from Kumi to Kampala.
[2] Assumes no revenue from back hauling, as indicated by middlemen.

[30] In the case of apparently perishable commodities such as high-value horticulture produce, the high market margins of middlemen are referred to as a strategy of risk factor pricing. In other words, marketing margins are high to cover the risk of losses of a high value product in transport. As will be shown, sweetpotato does not fit this scenario.

[31] An intensive study of potato marketing in Central Peru illustrates exactly the same phenomena, with middlemen often achieving negative revenues (Scott, 1985).

In this case, although the revenue per bag is much higher, USh 1,100 giving a net profit of 13.75%, the overall net revenue per trip (USh 11,000) is not excessive.[32] Neither of these two middlemen indicated any revenues from back hauling goods from Kampala to the sweetpotato producing areas.

These two case studies suggest that the margins of middlemen are not excessive that the larger price differential between farm-gate and retail prices (and consumer prices) are due to high marketing costs. The marketability of sweetpotato therefore does not appear to be hampered by the excess profits of certain actors in the chain. A systematic empirical study of the marketing margins for sweetpotato would help to dispel further doubts about this issue.

Unsophisticated handling practices

Limited evidence gathered for this study suggests that contrary to widespread notions, physical losses in the marketing chain for sweetpotato are low, despite the inherent perishability of the crop.[33] This is a direct result of the supply strategies that traders employ to ensure that there is a rapid turnover of stock. Nonetheless, it is widely believed among casual observers, as well as amongst some postharvest researchers, that poor handling increases postharvest losses by damaging roots and speeding up the deterioration of this already perishable crop.

Observations of handling procedures in Soroti and Kumi districts during the season when the main commercial crop is harvested confirmed that packing, handling, and transport of sweetpotatoes can be rough and unsophisticated. Workers appear to pay little attention to the relatively delicate nature of the product. Roots tend to be tightly packed in woven polyethylene sacks or gunny bags. They are often forced into the bags to maximize the capacity of the sack such that, with the addition of an extension or "head", a 100kg sack will hold about 120kg. This extra weight does not facilitate careful handling. Ignoring for the moment that current marketing and stock turnover procedures appear to avoid losses even under this handling regime, what is the basis for current handling practices and what would be the advantage of improving them?

The main reason for current handling practices, specifically the practice of overfilling sacks, is that the majority of the costs which the middlemen face are levied on a per sack basis. This includes district revenue authority tax, market dues, transport, even loading and unloading charges. In a wholesale business where margins are cut to a minimum (because of the number of competitors), there is a strong incentive to reduce costs by maximizing the amount transported in the minimum taxable (chargeable) units.

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[32] However, middlemen are not entirely blameless. Farmers in Soroti reported that sometimes middlemen would buy sweetpotatoes on credit and never return to pay for them. See also Fowler and Stabrawa (1993).

[33] The issue of sweetpotato postharvest losses is dealt with in later sections.

Box 2. Case study of a large-scale sweetpotato middleman.

Mr. W. transports sweetpotato variety Tanzania from Kumi district twice a week during the local sweetpotato season that lasts from September to January. He hires a Tata lorry and transports 100 bags per journey (maximum capacity of the truck), each bag containing 100-120 kg. Farmers charge USh 5,000 /bag and apparently this is constant throughout the September-January season. The hire of the truck for each journey is USh 5,000 for each bag transported (including fuel and a "turn" boy). Mr. W. sells the roots in the market for USh 11,000 per bag. During transport he must pay USh 100 /bag for Kumi District Development Fund (DDF), and a weigh bridge road toll of USh 100 /bag. He must also pay small amounts to traffic police who stop the truck for being overloaded. Market dues are USh 300 /bag sold. Other costs include USh 100 /bag for loading and USh 100 /bag for unloading (see Table 7.1).

It takes one day to load the truck (day one) and takes another whole day to transport the sweetpotatoes the 280km from Kumi to Kampala (day two). Mr. W. starts selling the morning after arriving in Kampala (day three). He sells some sweetpotatoes in Nakawa market, then moves on to Owino market to try and sell the rest. He may even move on to other markets if he has difficulty in selling. On the day of interview he had sold 64 bags in Nakawa market and was moving on to Owino market.

Sometimes he cannot sell all his sweetpotato on the first day in the market, so has to try to sell it on the next day. He can keep the sweetpotatoes for about 3 to 4 days before they start to deteriorate badly. Depending on the state of supply in the market, he may discount the price so that he can ensure some return from his sweetpotatoes. Mr. W. indicated that he avoids losses due to rotting by discounting the price to sell them more quickly. He sometimes experiences big one-off losses if the truck breaks down. Most often this delays his sweetpotatoes reaching the market in one day and he is more likely to have to discount the price.

Mr. W. said that he felt the profits in the sweetpotato wholesale trade were poor and that on some trips he even lost money when the market was over-supplied. He blames this on the high cost of transport and the large numbers of competing traders.

This seems unlikely to change until taxation measures are revised to a per kilogram basis, or transport costs are greatly reduced.

Although improvements in handling would not substantially reduce physical postharvest losses (these are already low, see discussion below), it might be justified in terms of better root quality. However, improved handling of sweetpotatoes will not occur until there is a price premium for high quality roots. At present sweetpotato is mainly consumed by low-income groups in urban centers. People eat it because it is cheap; quality is not the overriding issue. Mwesigwa (1995) demonstrates a negative correlation between income and sweetpotato consumption levels—suggesting a negative income elasticity of demand, and that the crop is viewed as an inferior good.

Box 3. Case study of medium-scale sweetpotato middleman.

Mr. S. transports his sweetpotatoes from Makinda Buyahire sub-county, Mukono district, about 40km from Kampala. He usually transports 10 bags of Buyanga and Kayanga varieties. The sweetpotatoes are not his own; he buys them at USh 8,000 /bag. These are then sold in the market for about USh 15,000 /bag. It takes about 2-3 hours to sell all of the sweetpotatoes.

From September – January, Mr. S. transports sweetpotatoes about twice a week, but from February to August he reduces his trips to about once per week because of the limited supply of sweetpotato. He doesn't transport every day because he can't always find sweetpotatoes to buy or sell. Also, there are a lot of other traders selling sweetpotato. He makes a deal with the other traders about who is going to sell on which day, which works out to be about twice a week for him.

Fuel for transport for the round trip journey costs about USh 40-45,000. Hire of the truck costs between USh 7,000 and 8,000 per trip; he pays USh 500 to load all the bags on the pickup truck; and market dues are USh 500 /bag (see Table 7.2).

When transporting, Mr. S. leaves home at 10:00 p.m. (to avoid revenue tax and traffic police) and arrives in the market at 1:00 a.m. He sleeps in the truck and sells his sweetpotatoes early in the morning. Sometimes he has to stay overnight with friends, in which case he leaves his sweetpotatoes with security people in the market; this costs USh 500.

Table 7.2. Revenues of a small-scale middleman transporting 10 bags of sweetpotato from Mukono District to Kampala city markets.

Item	Cost per bag	Total
Costs		
Sweetpotato	8,000	80,000
Fuel		45,000
Hire of pick-up truck		8,000
Loading truck		500
Market fees	500	5,000
Security		500
Local taxes/police	0	0
Total costs	**8,500**	**139,000**
Revenue[1]		
Sale of sweetpotatoes	15,000	150,000
Net revenue		**11,000**
Net revenue per bag		**1,100**

[1] Assumes no revenue from back hauling, as indicated by middlemen.

Improved handling (e.g. technologies or practices) which could increase the price of sweetpotato (there must be a price premium as an incentive to change practice[34]) would not be welcomed by low-income groups who rely on cheap sweetpotatoes as a major source of food.[35]

Sweetpotatoes are not carefully handled in transit, particularly in terms of over-filling bags. This is a direct result of high transport costs and taxes which are levied on a per bag basis. Improving handling may not reduce physical losses in transport, as these are already low. Although it might be argued that improved handling would improve the quality of roots, it seems doubtful whether this would be an advantage. Improved handling would not attract a price premium because sweetpotato is a food generally consumed by low-income groups, and as an inferior good the crop would be expected to demonstrate a low price-elasticity of demand. This supposition needs to be verified by a systematic empirical study.

High postharvest losses in the marketing chain

Of all the mistaken notions of the postharvest sector and of the marketing chain in particular, those surrounding postharvest losses appear to be the most persistent and illogical. Greeley (1982) describes it as the myth of the soft third option for increasing food availability (the other options are more food production and better distribution of the food that has been produced). Estimates that indicate the high level of losses in the marketing chain abound. For example, Fowler and Stabrawa (1993) suggest that overall losses in the sweetpotato marketing system in Uganda may be as high 37%.

In the needs assessment farmers did not mention losses at the farm level as a problem associated with sweetpotato.[36] Traditional practices in food-scarce rural communities are unlikely to persist for very long if they cause substantial quantities of food to be lost. At the farm level, the term 'loss' is often misleading. For example, in Soroti the needs assessment found that in marketing sweetpotato, some would be discarded in the field as unmarketable (due to size or weevil damage). These roots, however, would not simply be thrown away; but peeled, crushed, and dried to make *inginyo* (for sweetpotato flour).

In other words, what is apparently a loss actually has an alternative use (an opportunity cost). In Iganga, farmers said that excess sweetpotatoes, which they could not sell and which could not remain in the ground any longer, were given away rather

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[34] Even a price premium may not be sufficient to initiate a change in practice. The World Bank (1993) cites the example of the price premium for improved coffee quality. In this example, although hand grading would increase the value of the produce, the high cost of labor proved a disincentive. Mediocre quality with low but consistent marketing margins appears to be the preferred route.

[35] Greeley (1987) documents a similar situation with respect to rice quality in Bangladesh. Technology to improve rice quality was not readily adopted because improved quality did not produce a price premium. The urban poor wanted abundant cheap food of mediocre quality, not high priced, high quality food grains.

[36] However, some losses undoubtedly do occur, particularly in the drier districts. The point being made here is that levels of loss are not sufficiently great to be perceived as a problem by farmers in their particular income or food security context.

than leaving them to rot. This might be seen as a loss of an otherwise storable commodity. However, supporting people in the community who are less fortunate is an important part of the "moral" economy and is often part of a reciprocal support system.

Evidence from wholesalers suggests that physical losses are low, with the exception of the case of transport failures. Again, large-scale and persistent losses would be surprising. The marketing strategy used by middlemen relies on judging the market supply situation and discounting prices to sell stock quickly. Middlemen hold sweetpotatoes for only three to four days. The examples cited in the marketing case studies (see Boxes 2 and 3) show that margins are so small that middlemen could not stay in business for long if physical losses were significant and occurred on a regular basis.

Retailers at the end of the chain can be expected to suffer the highest losses because the crop has been out of the ground for the longest time and are, therefore, most vulnerable to deterioration. However, losses do not appear to be a problem in this case either. Retailers are often women traders working on a small scale. They buy small amounts of sweetpotato, usually one bag, and sell most of these roots in one day. They also quickly discount prices to help ensure a rapid turnover of stock. A recent empirical study on losses in the retail cassava (which is probably more perishable than sweetpotato) markets in Kampala showed that physical losses are less than 2%, but that economic losses can be as high as 20% (Ocoth, 1995). It would be surprising if figures for sweetpotato differed substantially from those for cassava.

Current marketing strategies have evolved in such a way as to avoid substantial physical losses. However, the cost of these strategies is a risk of economic losses, particularly at the retail level. Perhaps the most realistic conclusion is that sweetpotato is a low-priced commodity. Current economic losses associated with its marketing will persist until there are additional incentives to reduce them.

8. Consumption: Prospects for Expanding Utilization

The discussion in the previous section about marketing highlights the fact that the current market for fresh sweetpotato in Uganda is limited and at times oversupplied. Current yields combined with the low price for the crop often result in only modest net returns to farmers. Even though many areas in Uganda have a high potential for sweetpotato production, these areas also provide production opportunities for other crops. Farmers in some of these high-potential areas have opted to respond to prevailing prices by expanding output of other commodities, e.g. beans in Mbarara, potatoes in Kabale and Kabarole. However, in Kumi, Soroti, and Lira districts (in northeastern Uganda), given agro-climatic constraints, sweetpotato production has a comparative advantage despite its low market price. In addition, in these districts the decline in cassava production due to ACMVD has generated a surge in sweetpotato production in local cropping systems. As a result, sweetpotato cultivation continues to represent a primary livelihood strategy for a significant portion of the rural population. Development of new sweetpotato markets would have a significant impact on sweetpotato producers in these districts. Widening the utilization base of the crop through product development is one approach to market development.

As discussed earlier, value-added sweetpotato processing has strong potential in the current economic environment in Uganda. However, technical options for food processing need to be tested within the wider context of the food system. As will become apparent, value-added processing options not only need to be technically robust, they also need to demonstrate a competitive advantage over products already on the market. The following discussion examines the feasibility of one of these technical options, and highlights research and policy issues which still need to be tackled.

Current Consumption and Processing Practices

Traditional processing and consumption practices for starchy staples in Uganda are generally unsophisticated. Consumption is either in fresh or processed form. Processing is restricted to drying the staple and either rehydrating or making flour from it. In the case of cassava, cyanide must be removed and starch modified by fermentation.[37] The most common method of preparation and consumption of sweetpotato in Uganda is to boil or steam the fresh roots. This is the main method practiced in Iganga, Kabale, Mbarara, Kabarole, and Masindi according to the needs

[37] This is in contrast to the traditional food processing cultures in South and East Asia which have reached a high degree of sophistication, with a diversity of end uses for starchy staples, particularly noodles.

assessment.[38] In these areas, farmers indicated that they occasionally roasted the roots. The alternative method of consuming sweetpotato is either to slice or crush and then to dry it. In the former case, the dried slices are subsequently re-hydrated by boiling in water. In the latter case, the dried sweetpotato is ground into flour and, when mixed with sorghum flour, is cooked to form a stiff porridge or bread called *atapa*. Drying is the only true form of sweetpotato processing.[39]

As previously indicated (Chapter 4), drying was encountered at sites in Soroti, Kumi, and northern Luwero. Even in these districts, however, when it is available, sweetpotato is consumed fresh and cooked by boiling or steaming. Farmers at all three of these locations said they preferred to eat fresh rather than dried sweetpotato.

The sweetpotato is preserved by solar drying. Sliced or crushed sweetpotato roots are either placed on a large flat rock if this is available, or else placed in another part of the homestead compound where the ground has been prepared by spreading and drying cow dung. Drying the sweetpotato can take two to three days depending on the weather. When it is necessary to dry sweetpotato (the onset of the long dry season in November), it is also the season best suited to drying. Sunny days with little cloud cover persist. Unseasonal rainfall during this time can disturb the process and on occasion it will rain on the partly-dried sweetpotato. This results in the product turning black or dark gray.

Potential for Expanding the Practice of Drying Sweetpotato

Researchers frequently suggest introducing the processing of sweetpotato into dried chips into districts where drying is not currently practiced so that sweetpotato can be converted into a value-added product (personal communication, Dr. Mpango, Dept. of Chemistry, MUKLA). Based on discussions with farmers in areas where dried sweetpotato is not part of the regular diet, this type of product would not be acceptable for home consumption.

A lack of knowledge of simple processing techniques is not a constraint. Many older individuals interviewed in districts where solar drying is currently not observed explained that this was a common practice in the past.[40] Furthermore, marriages in Eastern Uganda often result in the women moving from districts (e.g., Soroti and Kumi) where they are accustomed to both drying the crop and eating foods made from the

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[38] It has been suggested that drying sweetpotato is also practiced in Iganga, but that householders there, due to the social stigma attached to this food, will not admit this to researchers (personal communication Dr. Mpango, Department of Chemistry, MUKLA).

[39] An exception to this was the production of alcohol in Kumi and Soroti districts which has not been covered by this study.

[40] It is unclear how knowledge of this practice was gained or why it was abandoned. Possibly it was part of locally legislated food security measures. Certainly in the past, villages were required to produce certain amounts of sweetpotato as a food security measure. This was enforced by village chiefs and local administrative systems. These systems have ceased to function for this type of activity. Perhaps this explains why the practice of drying has also been abandoned.

dried product to, for example Iganga, where this is not practiced. But this inter-district migration has failed to popularize and spread the practice. The fact that farmers associate dried sweetpotato with famine may have resulted in the product being perceived as a low-status food. This was certainly the view expressed by farmers during the needs assessment in Mbarara, Kabale, and Kabarole, and even Iganga. The key issue that emerges is that the practice of drying sweetpotatoes is not constrained by a knowledge gap, but by a lack of desire or incentive to do so.

Despite the lack of desire among those who were not accustomed to consume dried sweetpotato, farmers at the case study sites showed a great willingness to dry the crop if there was a ready market for it. As in other cases, finding a market for the dried sweetpotato was cited as a problem. What then is the feasibility of increasing the market for sweetpotato by using either fresh roots or sweetpotato flour made from dried chips in processed products?

Feasibility of Potential Products: The Case of Sweetpotato Bread

As mentioned in Chapter 2, a sister study to the needs assessment survey was carried out in Kampala to assess the feasibility and potential of sweetpotato processed products (see Hall, Hagenimana, and Low, forthcoming). The study attempted to assess the potential of sweetpotato as a source of starch to substitute for imported wheat flour in existing processed products (bread, chapati, and mandazi), currently available in Kampala. The research method was to actually use sweetpotato to produce these target processed products at bakeries as well as chapati and mandazi outlets. To illustrate some of the problems encountered, the production of sweetpotato bread is discussed below.

For this study two types of sweetpotato bread were produced: the first using grated roots and the second using sweetpotato flour. In both cases, the sweetpotato variety Tanzania was used. Consumer acceptability trials suggested that sweetpotato bread most closely resembled wheat bread when it was made using a salt bread recipe (the test bakery used this recipe for its wheat bread). The production costs illustrated in Table 8.1 compare the cost of ingredients and other inputs of the salt bread recipe using both solely wheat, and the sweetpotato-wheat mix.

The establishment in Kampala where the bread was produced is a medium-sized bakery which produces about 80,000 loaves per month. The prices used in the cost comparison are below the market prices that were current in Kampala at the time of the survey (November 1994). In November, the price of sweetpotato was at its lowest, USh 150 per kg; by the first quarter of 1994 the price had risen to USh 250 per kg.

Comparing the costs of production indicates that using grated sweetpotato decreases the net revenue per loaf resulting in a decrease in the revenue-cost ratio of 15.3%. The use of sweetpotato flour as a wheat substitute increases the net revenue per loaf by 3.6 USh (1.6%) and gives a 2.4% increase in the revenue-cost ratio.

Table 8.1. Comparison of production costs (USh) for wheat and sweetpotato breads, made using the same salt bread recipes as used for wheat bread.

	Wheat flour			Grated sweetpotato (Tanzania)			Sweetpotato flour (Tanzania)		
	Price/unit	Units	Total	Price/unit	Units	Total	Price/unit	Units	Total
Wheat flour (kg)	700	25.00	17,500	700	21.00	14,700	700	21.00	14,700
Sugar (kg)	820	0.25	205	820	0.80	656	820	0.80	656
Sweetpotato (kg)	-	0.00	0	150	10.50	1,575	-	0.00	0
Sweetpotato flour (kg)	-	0.00	0	-	0.00	0	500	4.20	2,100
Yeast (kg)	2,468	0.10	247	2,468	0.10	247	2,468	0.10	247
Improver (kg)	2,222	0.45	1,000	2,222	0.45	1,000	2,222	0.45	1,000
Fat (kg)	1,600	1.00	1,600	1,600	1.00	1,600	1,600	1.00	1,600
Electricity	-	-	11,375	-	-	11,375	-	-	11,375
Labor	-	-	1,610	-	-	4,062	-	-	1,610
Depreciation	-	-	124	-	-	124	-	-	124
Ground rent, licenses, etc.	-	-	22	-	-	22	-	-	22
Water services	-	-	217	-	-	217	-	-	217
Total costs	-	-	**33,900**		-	**35,578**	-	-	**33,651**
Revenue	700	70.00	49,000	700	70.00	49,000	700	70.00	49,000
Net revenue			15,100			13,422			15,349
Revenues per loaf			215			192			219.20
Net revenue cost ratio			0.44			0.37			0.45
Change in revenue cost ratio (%)			0			-15.30			2.40

Assumptions:

Wheat flour cost: Bulk purchase, delivered from grain millers @ 35,000 USh per 50kg bag.

Sugar cost: Bulk purchase @ 41,000 USh per 50kg bag.

Yeast cost: Bulk purchase @ 80,000 USh per box of 72 450g packets.

Sweetpotato flour costs: Dry chips @ 300 USh per kg (seasonally adjusted); transport 50 USh per kg; milling 50 USh per kg; commercial mark-up 100 USh per kg; total cost 500 USh per kg.

Sweetpotato root costs: Kampala market prices 1995.

Labor costs: Monthly bill for medium-sized bakery 1.84 million USh; 80,000 loaves per month; 23 USh per loaf.

Additional labor costs: Grating sweetpotato: 2.8 person minutes per kg; washing 0.4 person minutes per kg; grating 41.5 person minutes per kg. Assuming an 8-hour day, additional labor equivalent to 0.093 person days per kg @ 2,500 USh per day = 232.5 USh per kg.

Depreciation costs: Equipment and building costs 117 million USh @ 10% p.a. equivalent to 1.7 USh per loaf.

Electricity costs: Monthly bill for medium sized bakery 1.3 million USh, equivalent to 16.25 USh per loaf.

Cost of ground rent, licenses, etc.: For medium-sized bakery, 300,000 USh per year, 0.313 USh per loaf.

Cost of water services: 250,000 per month, equivalent to 3.1 USh per loaf.

Grated Sweetpotato

At the prevailing cost of inputs, the technology for processing grated sweetpotato does not represent an economically viable substitute for wheat flour for several reasons:

- The proportion of wheat flour for which sweetpotato can be substituted without reducing the quality of the product is relatively low (16%).
- Although the cost of sweetpotato roots is low, USh 150 /kg compared to USh 700 /kg for wheat flour, the cost is actually quite high for processing sweetpotato (peeling, washing, and grating) into a form that can directly substitute for wheat flour in the bread-making process. Processing represents an additional cost of USh 232.5 /kg of sweetpotato, and losses of 10% in weight due to peeling. The final cost of processed sweetpotato is approximately USh 400 /kg. On a dry weight basis, therefore, the cost of sweetpotato is equivalent to USh 1,320 /kg (assuming a 30% dry matter content) or USh 800 (assuming a 30% dry matter content plus 20% moisture content in wheat flour). Grated sweetpotato represents a more expensive form of starch than wheat flour.
- The assumption that sweetpotato would replace some of the sugar in the bread did not turn out to be the case for the bread produced for this study. The recipe for the sweetpotato bread actually contained more sugar than the standard recipe for salt bread which it most closely resembled (not so for sweetpotato flour bread, see below). The comparison of costs of producing the salt bread recipe and the sweetpotato recipe may be slightly biased in that sweetpotato bread uses more sugar than its wheat counterpart (for both sweetpotato flour and grated sweetpotato recipes). This is an anomaly in the recipe rather than a suggestion that the use of sweetpotato has an associated need for extra sugar. The net revenue cost ratio remains negative even when using equal amounts of sugar in both bread recipes; therefore, grated sweetpotato does not represent a viable substitute for wheat flour (Table 8.2).
- The use of grated sweetpotato is also associated with a hidden cost which is not reflected in the production cost comparison. Processing dirty roots does not lend itself well to a food processing industry which tends to rely on clean, dry ingredients which can be easily bought and which come in a ready-to-use form. This is particularly the case with wheat flour which has a well established and reliable supply chain.
- Seasonal price fluctuations which characterize sweetpotato supply are not a factor in wheat flour supply.

Table 8.2. Comparison of production costs (USh) for wheat and sweetpotato bread, made using the same sugar recipe.

	Wheat flour			Grated sweetpotato (Tanzania)			Sweetpotato flour (Tanzania)		
	Price/unit	Units	Total	Price/unit	Units	Total	Price/unit	Units	Total
Wheat flour (kg)	700	25.00	17,500	700	21.00	14,700	700	21.00	14,700
Sugar (kg)	820	0.80	656	820	0.80	656	820	0.80	656
Sweetpotato (kg)	-		0	150	10.50	1,575	-	0.00	0
Sweetpotato flour (kg)	-	0.00	0	-	0.00	0	500	4.20	2,100
Yeast (kg)	2,468	0.10	247	2,468	0.10	247	2,468	0.10	247
Improver (kg)	2,222	0.45	1,000	2,222	0.45	1,000	2,222	0.45	1,000
Fat (kg)	1,600	1.00	1,600	1,600	1.00	1,600	1,600	1.00	1,600
Electricity	-	-	11,375	-	-	11,375	-	-	11,375
Labor	-	-	1,610	-	-	4,062	-	-	1,610
Depreciation	-	-	124	-	-	124	-	-	124
Ground rent, licenses, etc.	-	-	22	-	-	22	-	-	22
Water services	-	-	217	-	-	217	-	-	217
Total costs	-	-	**33,900**		-	**35,578**	-	-	**33,651**
Revenue	700	70.00	49,000	700	70.00	49,000	700	70.00	49,000
Net revenue			15,100			13,422			15,349
Revenues per loaf			215			192			219
Net revenue cost ratio			0.44			0.37			0.45
Change in revenue cost ratio (%)			0			-11.53			6.95

Assumptions:

Wheat flour cost: Bulk purchase, delivered from grain millers @ 35,000 USh per 50kg bag.

Sugar cost: Bulk purchase @ 41,000 USh per 50kg bag.

Yeast cost: Bulk purchase @ 80,000 USh per box of 72 450g packets.

Sweetpotato flour costs: Dry chips @ 300 USh per kg (seasonally adjusted); transport 50 USh per kg; milling 50 USh per kg; commercial mark-up 100 USh per kg; total cost 500 USh per kg.

Sweetpotato root costs: Kampala market prices 1995.

Labor costs: Monthly bill for medium-sized bakery 1.84 million USh; 80,000 loaves per month; 23 USh per loaf.

Additional labor costs: Grating sweetpotato: 2.8 person minutes per kg; washing 0.4 person minutes per kg; grating 41.5 person minutes per kg. Assuming an 8-hour day, additional labor equivalent to 0.093 person days per kg @ 2,500 USh per day = 232.5 USh per kg.

Depreciation costs: Equipment and building costs 117 million USh @ 10% p.a. equivalent to 1.7 USh per loaf.

Electricity costs: Monthly bill for medium sized bakery 1.3 million USh, equivalent to 16.25 USh per loaf.

Cost of ground rent, licenses, etc.: For medium-sized bakery, 300,000 USh per year, 0.313 USh per loaf.

Cost of water services: 250,000 per month, equivalent to 3.1 USh per loaf.

Sweetpotato Flour

The cost comparison shows a small economic advantage for the sweetpotato flour recipe over the wheat bread recipe. This relatively small benefit appears as a result of two of the factors which were also operating in the case of the grated sweetpotato recipe. The first is that sweetpotato flour can substitute for only 16% of the wheat flour. Even at this low proportion, there was evidence of quality deterioration in the sweetpotato bread. Secondly, although sweetpotato flour can arrive at the bakery in a ready processed and convenient-to-use form, an established supply chain for the product does not exist. Also, sweetpotato flour is relatively expensive, USh 500 /kg (exacerbated by the seasonality of supply) compared to USh 700 /kg for wheat flour.

In the case of the sweetpotato flour recipe, the increase in net revenue per loaf approaches 5%, USh 219 compared with USh 209 for the wheat bread. This is also reflected in the 6.9% increase in the net revenue cost ratio. However, even in the case of the sweetpotato flour recipe, the economic benefits are not substantial.

Under the price and technology conditions at the time of the feasibility study, the use of sweetpotato in bread production in medium-scale bakeries in Kampala did not seem appropriate. The following scenarios examine how this outcome would alter if prices and technologies change.

Scenario I: High-Cost Wheat Flour

Assumptions: The cost of wheat flour increases by 50%, but sweetpotato costs and processing technology remain the same.

Probability: This would require a dramatic increase in world prices for wheat flour or a restriction of access to world wheat markets. An increase in world prices by such a large factor, though not impossible, would be unlikely given the diversity of sources of production. Restriction of access to world markets might result from instability in transit-route countries such as Kenya.

Impact on cost of production. Using the assumption that wheat prices increase by 50% the use of grated sweetpotato will increase the net revenue per loaf by USh 2.5 (3%) and increase the net revenue cost ratio by 3.3% (Table 8.3). This benefit is probably insufficient to prompt a change in practice. However, the use of sweetpotato flour provides a substantial benefit by increasing revenue per loaf by USh 30 (36%) as well as increasing the net revenue-cost ratio by 42.5%. This suggests that sweetpotato flour substitution would be an economically viable proposition with substantial benefits for the bakery. The set of assumptions used in this comparison, however, suggests that the price of bread would remain constant. A scarcity of wheat flour would raise the price of bread, the effect of which would be to reduce the economic benefit of wheat flour substitution to a certain degree – the savings would be a smaller proportion of the value of the product.

Table 4.1. Agro-ecological zone and crop production levels (metric tons) of selected staples by district.[1]

District	Maize		Finger millet		Sorghum		Beans		Simsim		Cassava		Sweet-potato	% of total sweetpotato production[2]	Matooke		Potato	
High altitude, temperate																		
Kabale	14,638		1,956		124,254		130,541		-		1,030		98,313	7%	63,810		101,587	
Kapchorwa	59,060		853		-		584		-		899		755	0%	27,235		75	
Kasese	4,089		743		198		5,741		-		46,713		3,435	0%	43,506		662	
Sub-total	77,787	18%	3,552	1%	124,452	48%	136,866	27%	0	0%	48,642	1%	102,503	8%	134,551	4%	102,324	37%
Northern and Eastern short grassland (medium rainfall)																		
Apac	4,487		20,881		7,429		7,865		20,059		618,709		6,023	0%	2,275		-	
Arua	7,192		18,334		10,033		13,860		5,045		562,211		10,171	1%	-		-	
Kumi*	-		-		-		-		-		-		-	-	-		-	
Lira	6,084		61,886		31,345		7,053		12,751		183,896		36,336	3%	338		-	
Mbale[3]	39,418		7,136		328		5,118		-		136,447		5,594	0%	358,150		-	
Moyo	5,694		496		6,128		-		5,361		139,684		23,462	2%	-		-	
Nebbi	3,703		732		1,158		5,638		805		597,708		2,522	0%	8,459		-	
Soroti*	-		-		-		-		-		-		-	-	-		-	
Tororo	11,961		96,352		8,974		628		76		855,960		59,257	4%	78,413		260	
Sub-total	78,539	18%	205,817	60%	65,395	25%	40,162	8%	44,097	97%	3,058,615	62%	143,365	12%	447,635	12%	260	0%
Southern and Eastern tall grassland (high rainfall)																		
Bundibugyo	747		26		52		3,228		-		73,406		2,408	0%	12,113		130	
Bushenyi	1,724		22,436		7,700		22,013		-		8,530		112,428	8%	991,738		8,042	
Holima	3,756		7,111		2,781		18,326		-		66,314		53,953	4%	26,263		3,637	
Iganga	71,133		14,314		1,397		20,687		-		257,477		112,406	8%	60,557		209	
Jinja	13,867		1,458		78		17,813		76		16,754		26,113	2%	24,619		-	
Kabarole	7,398		14,584		11,290		30,330		-		182,168		95,858	7%	171,360		-	
Kamuli	52,070		21,689		168		7,466		129		203,302		135,397	10%	32,634		13,547	
Luwero	8,518		680		1,555		15,085		33		63,060		56,041	4%	51,677		2,903	
Masaka	4,964		263		3,908		13,673		-		31,483		44,840	3%	473,482		1,240	
Masindi	16,715		2,663		-		5,268		37		232,000		18,424	1%	7,804		-	
Mbarara	28,913		27,137		10, 028		38,893		-		15,574		28,406	2%	102,111		13,820	
Mpigi	1,861		5		2,591		10,493		-		97,650		125,989	9%	115,867		1,006	
Mubende	26,294		3,813		9,264		39,368		33		53,772		118,153	9%	491,022		14,503	
Mukono	11,887		3,873		2,743		49,619		1,272		459,140		95,114	7%	168,546		-	
Rakai	21,470		813		5,430		17,468		-		97,252		37,805	3%	334,477		11,505	
Rukungiri	5,598		12,202		10,442		20,633		-		6,065		51,651	4%	273		100,730	
Sub-total	276,915	64%	133,067	39%	69,427	27%	330,363	65%	1,580	3%	1,863,947	37%	996,833	80%	3,064,543	84%	171,272	63%
Total	433,241	100%	342,436	100%	259,274	100%	507,391	100%	45,677	100%	4,971,204	100%	1,242,701	100%	3,646,729	100%	273,856	100%

[1]As there are discrepancies between Agricultural Census and annual production data, these figures should be interpreted with caution.
[2]Totals do not include figures for all districts and therefore should be interpreted with caution.
[3]Mbale District includes some high altitude areas.
* no data collected due to civil disturbance.
Source: Agricultural Census 1991, (MAAIF 1992).

However, a more likely scenario is that a sweetpotato product would be discounted, passing on benefits to the consumer while the producer would continue to benefit from improved returns – albeit, slightly lower than the proportion suggested above.

Scenario II: Low-Cost Sweetpotato Flour

Assumption. The price of sweetpotato flour to the bakery can be reduced to USh 150 /kg (price reduction of 70%).

Probability. This would require the development of a production and supply chain for sweetpotato flour because currently it is not a traded commodity. This is a formidable challenge because of the following:

- lack of demand for sweetpotato flour;
- wide spread availability of high quality wheat flour;
- availability of alternative low cost flours, including cassava, posho, millet, and sorghum;
- technical problems associated with the production of high quality sweetpotato flour, related particularly to its hygroscopic nature; and
- seasonal nature of dried sweetpotato production.

However, if these problems are disregarded, a price of USh 150 is comparable with that for cassava flour.

Impact on the cost of production. Using the assumptions presented in Table 8.4, the use of sweetpotato flour increases the revenue per loaf by USh 31 (15%) and increases the net revenue cost ratio by 22.5%. This would represent a substantial benefit to the bakery.

Scenario III: Labor-Saving Technical Change for Grating Sweetpotato

Assumptions. A mechanical grater can be developed that will reduce the costs associated with processing sweetpotato into a form convenient for breadmaking.

Probability. Mechanical graters of this type are widely available in the food processing industry and at a scale suitable for a medium sized bakery. There is a high probability that this type of grater could be introduced at a cost of approximately USh 1 million (US$1,000).

Impact on cost of production. The use of a mechanical grater would increase the net revenue per loaf by USh 17.4 (8%), and increase the net revenue-cost ratio to 12.29 %

Table 8.4. Comparison of production costs (USh) for wheat and sweetpotato breads, made using the same sugar recipe, and assuming the cost of sweetpotato flour is reduced to 150 USh per kg.

	Wheat flour			Sweetpotato flour (Tanzania)		
	Price/ unit	Units	Total	Price/ unit	Units	Total
Wheat flour (kg)	700	25.00	17,500	700	21.00	14,700
Sugar (kg)	820	0.80	656	820	0.80	656
Sweetpotato (kg)	-		0	-	0.00	0
Sweetpotato flour (kg)	-	0.00	0	150	4.20	638
Yeast (kg)	2,468	0.10	247	2,468	0.10	247
Improver (kg)	2,222	0.45	1,000	2,222	0.45	1,000
Fat (kg)	1,600	1.00	1,600	1,600	1.00	1,600
Electricity	-	-	11,375	-	-	11,375
Labor	-	-	1,610	-	-	1,610
Depreciation	-	-	124	-	-	124
Ground rent, licenses, etc.	-	-	22	-	-	22
Water services	-	-	217	-	-	217
Total costs	-	-	**34,351**			**32,189**
Revenue	700	70.00	49,000	700	70.00	49,000
Net revenue			14,649			16,811
Revenues per loaf			209			240
Net revenue cost ratio			0.43			0.52
Change in revenue cost ratio (%)			0			22.55

Assumptions:
Wheat flour cost: Bulk purchase, delivered from grain millers @ 35,000 USh per 50kg bag.
Sugar cost: Bulk purchase @ 41,000 USh per 50kg bag.
Yeast cost: Bulk purchase @ 80,000 USh per box of 72 450gram packets.
Sweetpotato flour costs: 150 USh per kg.
Labor costs: Monthly bill for medium-sized bakery 1.84 million USh; 80,000 loaves per month; 23 USh per loaf.
Depreciation costs: Equipment and building costs 117 million USh @ 10% p.a. equivalent to 1.7 USh per loaf.
Electricity costs: Monthly bill for medium sized bakery 1.3 million USh, equivalent to 16.25 USh per loaf.
Cost of ground rent, licenses, etc.: For medium-sized bakery, 300,000 USh per year, 0.313 USh per loaf.
Cost of water services: 250,000 per month, equivalent to 3.1 USh per loaf.

(Table 8.5). This would represent a significant benefit to the producer. The cost of production under this set of assumptions also indicates that the use of fresh, grated sweetpotato would provide a more favorable economic benefit than the use of sweetpotato flour under current production and price conditions. The introduction of a mechanical grater probably represents the most feasible scenario in which sweetpotato can play a significant role in breadmaking.

In the current price and technological environment of medium-scale bread production, the use of either fresh grated sweetpotato or sweetpotato flour is not economically feasible. This is the result of the relatively small price differential between wheat flour and sweetpotato as a starch source. The lack of economic benefits is

Table 8.5. Comparison of production costs (USh) for wheat and sweetpotato breads, using a mechanical grater to prepare sweetpotato for the bread-making process.

	Wheat flour			Grated sweetpotato (Tanzania)			Sweetpotato flour (Tanzania)		
	Price/unit	Units	Total	Price/unit	Units	Total	Price/unit	Units	Total
Wheat flour (kg)	700	25.00	17,500	700	21.00	14,700	700	21.00	14,700
Sugar (kg)	820	0.80	656	820	0.80	656	820	0.80	656
Sweetpotato (kg)	-	0.00	0	150	10.50	1,575	-	0.00	0
Sweetpotato flour (kg)	-	0.00	0	-	0.00	0	500	4.20	2,100
Yeast (kg)	2,468	0.10	247	2,468	0.10	247	2,468	0.10	247
Improver (kg)	2,222	0.45	1,000	2,222	0.45	1,000	2,222	0.45	1,000
Fat (kg)	1,600	1.00	1,600	1,600	1.00	1,600	1,600	1.00	1,600
Electricity	-	-	11,375	-	-	11,375	-	-	11,375
Labor	-	-	1,610	-	-	4,062	-	-	1,610
Depreciation	-	-	124	-	-	131	-	-	124
Ground rent, licenses, etc.	-	-	22	-	-	22	-	-	22
Water services	-	-	217	-	-	217	-	-	217
Total costs	**-**	**-**	**34,351**		**-**	**35,585**	**-**	**-**	**33,651**
Revenue	700	70.00	49,000	700	70.00	49,000	700	70.00	49,000
Net revenue			14,649			13,415			15,349
Revenues per loaf			209			192			219
Net revenue cost ratio			0.42			0.37			0.45
Change in revenue cost ratio (%)			0			12.29			6.95

Assumptions:

Wheat flour cost: Bulk purchase, delivered from grain millers @ 35,000 USh per 50kg bag.

Sugar cost: Bulk purchase @ 41,000 USh per 50kg bag.

Yeast cost: Bulk purchase @ 80,000 USh per box of 72 450g packets.

Sweetpotato flour costs: Dry chips @ 300 USh per kg (seasonally adjusted); transport 50 USh per kg; milling 50 USh per kg; commercial mark-up 100 USh per kg; total cost 500 USh per kg.

Sweetpotato root costs: Kampala market prices 1995.

Labor costs: Monthly bill for medium-sized bakery 1.84 million USh; 80,000 loaves per month; 23 USh per loaf.

Additional labor costs: Grating sweetpotato: 2.8 person minutes per kg; washing 0.4 person minutes per kg; grating 41.5 person minutes per kg. Assuming an 8-hour day, additional labor equivalent to 0.093 person days per kg @ 2,500 USh per day = 232.5 USh per kg.

Depreciation costs: Equipment and building costs 117 million USh @ 10% p.a. equivalent to 1.7 USh per loaf.

Electricity costs: Monthly bill for medium sized bakery 1.3 million USh, equivalent to 16.25 USh per loaf.

Cost of ground rent, licenses, etc.: For medium-sized bakery, 300,000 USh per year, 0.313 USh per loaf.

Cost of water services: 250,000 per month, equivalent to 3.1 USh per loaf.

exacerbated by the low rate at which sweetpotato can substitute for wheat flour. The proportion of substitution appears to have reached a ceiling at 16% (without quality deterioration) and, therefore, under current circumstances the prospects of using sweetpotato as a wheat flour substitute are low. Among the scenarios which explored the effects of input price and technological change, the most realistic option for increasing the attractiveness of sweetpotato in bread-making is the introduction of a mechanical grater that would lower the cost of using fresh sweetpotato.

These observations suggest that, for sweetpotato to be used in bread production in Kampala, the following constraints need to be overcome:

- The price of sweetpotato roots needs to be substantially reduced. This requires major advances in production technology to increase yields. Alternatively, the use of sweetpotato should be advocated only in the major production areas where prices tend to be significantly lower, for example Soroti, Lira, and Kumi districts.
- The rate of substitution of wheat flour needs to be substantially increased. This is a major technical obstacle as it arises from underlying functional properties of sweetpotato starch.
- The hygroscopic nature of sweetpotato flour appears to place it at a disadvantage when compared to wheat flour. This is another major technical obstacle that would need to be resolved before sweetpotato flour could be advocated as a direct substitute for wheat flour in commercial-scale bakeries.

Conclusion

While technical and price obstacles to the use of sweetpotato in breadmaking are not insurmountable, they represent a significant challenge. The costs of production might be more favorable in small-scale bakeries in districts where sweetpotato is the major crop and its price is lower, in Lira, for example (personal communication, Dr. S. Nahdy, National Postharvest Programme).

The bottleneck for the product development process, however, does not seem to be just gaining information or solving technical problems. These are areas in which postharvest researchers have a comparative advantage. For novel processing ideas to take off, good market research is also needed to identify potential opportunities. Once identified, it is necessary to popularize these ideas and market the products. These tasks require entrepreneurial skill and flare, attributes more commonly found in the private sector rather than in public national research systems. Close collaboration with the private sector in these activities is essential if good ideas are to be taken up and actively pursued. Effort is still needed to fully develop the capability in the postharvest research program to undertake the necessary market research to identify the niche for processed products. Market research should look beyond human foods to include the possibility for animal feeds, using stored roots in particular. To that end the research

system would benefit from additional linkages and partnerships with the private sector, NGOs, and universities to exploit their ability to undertake these entrepreneurial and marketing research tasks.

9. Conclusions and Recommendations

This study has analyzed the role and importance of sweetpotato in Ugandan food systems, and the postharvest strategies which support it. The crop is strategically important in that it underpins farm-level food security (as a famine reserve staple), as well as being of absolute importance in its role as a dominant staple or co-staple. It is in this latter role that the crop—along with its constraints and potential—is so intrinsically woven with rural livelihoods and their future prospects. In these instances sweetpotato is the main source of food and cash income. Under the current technological scenario, the crop is only supporting the minimum of food and non-food requirements of the rural poor. Nevertheless sweetpotato is their best crop option. Recommendations for research and institutional policy which will support sweetpotato to continue to contribute and make improvements to the sustainability of rural livelihoods are discussed below. A summary is provided in Table 9.1. These recommendations are divided into three areas: geographic focus, technical research policy, and capacity-building and institutional policy.

Geographic Focus

This study indicates that the geographical focus of future postharvest technology development and transfer activities needs to be in the northeast districts of Uganda, i.e. Kumi, Soroti, and Lira. Other areas that should also be considered for development are those having similar agro-climates and where the food system is dominated by sweetpotato as a result of the decline in cassava production. Although documented information is not presently available, this would probably include many of the northern districts that previously relied heavily on cassava as a starchy staple. A rapid rural assessment to confirm this would be necessary. It is within this geographic area that sweetpotato has the greatest potential to contribute to the sustainability of rural livelihoods.

Research in the targeted districts needs to address two sweetpotato postharvest concerns: strengthening household food security and identifying and exploiting opportunities for value-added processing. Processed products for both human and animal feed should be considered.

Technical Research Policy

Technical research on sweetpotato postharvest issues needs to focus on four areas:

- in-ground storage and piecemeal harvesting;
- storage of sweetpotato;
- marketing issues; and
- processed products.

Table 9.1 Summary of constraints and potentials of sweetpotato postharvest strategies in different Ugandan food systems.

Role / location	Strategy	Components	Constraints	Potentials /needs
1. Predominant staple Sweetpotato has emerged as the main starch staple in areas where the traditional co-staple cassava has declined due to ACMVD. Sweetpotato is dominant in the food system. ***Sites**: Soroti, Kumi, Luwero districts (northern and eastern districts)*	IGSPH	• Menu of varieties • Staggered planting • Piecemeal harvesting • In-ground storage	• Availability of planting material • Varieties with postharvest characteristics • In-ground storage limited by climatic conditions	• Development of rapid multiplication methods • Identify nature of postharvest characteristics and include in crop improvement program
	SDS	• Slicing or crushing and drying of the roots • Storage in granaries or sacks • Re-drying to remove storage pests	• Farmer selection for storage • Pest infestation • Storage space • Re-drying is time-consuming	• Identify nature of storage characteristics and include in crop improvement program • Identification of appropriate pest management methods • Validation and dissemination of fresh storage technology
2. Complementary major staple Sweetpotato is one of a number of major grain and non-grain staples which are seasonally important in the food system. ***Sites**: Masindi, Kabarole, Kabale and Iganga districts (districts with favorable and or altitude modified climates)*	IGSPH	as for IGSPH in 1	as for IGSPH in 1	as for IGSPH in 1
3. Famine reserve crop Sweetpotato is consumed in gaps in the production calendar of the major staple. It is particularly important in years with production failures. Sweetpotato backstops the food system, but is not a major food staple. ***Sites**: Mbarara district (western and Lake Crescent districts)*	IGSPH	as for IGSPH in 1	as for IGSPH in 1	as for IGSPH in 1
4. Income source Sweetpotato is an important source of income either as a crop strictly for cash or, more commonly, as a source of revenue for small farmers who have few other income earning opportunities. ***Sites**: As a cash crop, Soroti, Kumi (main cash crop), Iganga (one of a number of cash crops), petty trading in all sweetpotato growing districts*	IGSPH	• Cash crop • Source of cash income/petty trading	• Low market price • "Inferior good" status • No market currently exists for processed products • Limited opportunities for farmer level value addition • Low returns to production	• Strengthen demand by exploring use in bread making in main production areas • Explore farm level value added processing, possibly integrated livestock systems • Undertake systematic empirical studies on demand elasticity, marketing margins and postharvest losses in the marketing chain

In-ground Storage and Piecemeal Harvesting

Availability of planting material. A menu of varieties plays a key role in the in-ground storage and piecemeal harvesting strategy, contributing a mixture of sweetpotato varieties with complementary production and postharvest characteristics. The lack of availability of desirable planting material, however, is a serious constraint. There is an immediate need to devise innovative methods of providing farmers with timely and adequate supplies of planting material of the desired varieties. Rapid multiplication techniques may be one approach.

Identification, characterization, and development of varieties with postharvest characteristics. Due to the overlap between production and storage, postharvest research directed toward the sub-sector employing in-ground harvest and piecemeal harvesting should focus on varietal selection and improvement for storage and utilization characteristics. There is already vast diversity in Ugandan sweetpotato germplasm. A medium-term research priority must therefore be to identify, characterize, and catalog which varieties farmers grow and which varietal attributes they value. This work should be linked with efforts to disseminate indigenous planting material to farmers (inter-district dissemination). This goal could be combined with efforts to teach farmers the techniques for rapid multiplication of planting material. A long-term research priority must be to develop improved sweetpotato varieties that have characteristics that fit farmers' criteria. In particular, an understanding of the physiological and biochemical basis of desired postharvest characteristics, and their heritability, should be a part of any long-term work to improve Ugandan germplasm.

Storing Sweetpotato

Since the decline in production of cassava and the consequent increase in dependence on sweetpotato, insect infestation of dried sweetpotato has raised concern. Insect infestation in dried sweetpotato becomes excessive during critical months of food shortage. Research aimed at addressing this situation needs to become a priority, because it is a significant cause of food insecurity, particularly in years with abnormally low rainfall.

Examination of dried sweetpotato slices and discussions with farmers indicated that some sweetpotato varieties store for longer than others—in both the sliced and dried form. However, farmers do not restrict drying and storage to the varieties that store best, neither do they separate the dried slices of different varieties for storage. This suggests that although the short shelf life of dried sweetpotato is a constraint to current practice (food security) the more fundamental constraints are those which prevent farmers from exploiting the storability of the varieties which they have already identified as superior.

The current constraints could be partially addressed by providing improved access to a range of varieties with desired characteristics (as recommended above)—farmer derived varieties exist with these characteristics and they should be exploited. This would help farmers plant the amount of specific varieties for drying based on how much they anticipate they will need to dry rather than on the amount of planting material available for any given variety. Improved access to varieties would also help farmers to plant in a more systematic fashion which would aid the separation of varieties at harvest. A clearer understanding of the reasons why farmers do not exploit the inherent storability of certain varieties, is a research need in this context. These issues may be related to the development of—or lack of—a commercial market chain for these dry products. The prospects for this process need to be investigated as this issue also relates to the prospects for novel uses and product development.

In the long term, the physiological and biochemical basis of these varietal differences, and their heritability, should be a part of any long-term work to improve Ugandan germplasm.

Technology for storage of fresh roots. Further adaptive testing and dissemination of low-cost storage for fresh roots would also strengthen food security in target areas. The technology would provide farmers with the option of storing sweetpotato for some time before drying it, extending the availability of uninfested dried sweetpotato into the months of greatest food shortage. On-farm adaptive testing of storage technology has indicated that it is a low-cost food security measure, with farmers using it to provide a supply of fresh roots in the dry season, as well as a mechanism to delay the slicing and drying of roots. It is strongly recommended that adaptive testing of on-farm storage is continued as a priority within the target area. This would determine both the storability of a range of farmer selected varieties, as well as assisting in the diffusion of the technology. In drought years this technology has the potential to act as a significant famine relief measure in the target areas.

Marketing Issues

Marketing margins. Evidence suggests that the margins of middlemen are not excessive and that the large price differential between farm-gate and retail (and consumer) prices are caused by high transport and then marketing costs. A systematic study of the marketing margins for sweetpotato would help dispel remaining doubts about the profits of the actors involved in this trade.

Handling in the market chain. Sweetpotatoes are not handled very carefully in transit, particularly in terms of over-filling bags. This is a direct result of high transport costs and taxes which are levied on a per bag basis. Improving handling may not reduce transport losses, as these are already low. Although it might be assumed that improved

handling would improve the quality of roots, it is doubtful whether this would provide a benefit to either traders or consumers. Improved handling would not attract a price premium because sweetpotato is a food generally consumed by low-income groups, and as an 'inferior good' the crop would be expected to demonstrate a low price elasticity of demand. This supposition needs to be verified with a systematic empirical study.

Processed Products

Economic feasibility of substituting sweetpotato for wheat flour. Case study evidence suggests that in the current pricing and technology environment, the use of sweetpotato as a wheat flour substitute may not be economically feasible in medium-sized bakeries in Kampala. More appropriate niches for sweetpotato need to be found where price factors would make sweetpotato a more competitive source of starch. This should be investigated further in the recommended target areas of Soroti, Lira and Kumi.

In general, while evidence in this study suggests that at present sweetpotato is not a feasible wheat flour substitute, if the following technical and price obstacles could be removed, the feasibility should be reassessed:

- The price of sweetpotato roots needs to be significantly reduced. This requires major advances in production technology to increase yields. Alternatively, the use of sweetpotato should only be advocated in the major production areas where prices tend to be significantly lower, for example Soroti, Lira and Kumi districts.
- The rate of substitution of wheat flour needs to be substantially increased. This is a major technical obstacle as it arises from underlying functional properties of sweetpotato starch. The hygroscopic nature of sweetpotato flour appears to place it at a disadvantage compared to wheat flour. This is an obstacle which would need to be overcome before sweetpotato flour could be recommended as a direct substitute for wheat flour in commercial scale bakeries.
- Significant increases in the price of wheat flour would improve the competitive advantage of sweetpotato for use in bakery products.

Sweetpotato does have a potentially important role in value-added processing. Further research is necessary to identify niche markets where sweetpotato has a competitive advantage. The use of sweetpotato for livestock feeds, particularly for pigs, should be considered. Much of the work needed in this area concerns market information, technology transfer and support of new agro-processing enterprises. Fundamental technical research is likely to be less important, this is discussed further in the context of capacity-building and institutional policy recommendations.

Capacity-Building and Institutional Policy

Weakness of current institutional arrangements. A notable feature of the sweetpotato postharvest issues discussed in this study is the systems nature of many of

the phenomena. This is reflected in two ways: sweetpotato is part of the wider food system; and the interrelated nature of this system, particularly production and postharvest components. The consequences of this for the commodity and disciplinary based research programs of Uganda—both dominant features of the current institutional framework—are that:

- These research structures are poorly suited to fully understand the complexities of the food system of which sweetpotato plays a part—hence weakening the identification of constraints and opportunities.
- There tends to be a separation of production and postharvest research as these are the mandate of distinct research programs—hence weakening opportunities for postharvest concerns to be embedded in production and particularly crop improvement programs.

Such institutional issues need to be considered if postharvest research is to make a meaningful contribution to the process of economic production. Closer collaborative links need to be created between postharvest research and research on sweetpotato breeding and production more generally. These links should be formalized with joint research programs.

Capacity-building. More emphasis needs to be placed on understanding current postharvest practices in the whole system—particularly farmers' and consumers' rationale for their practices—with a view to identifying where gaps and constraints occur. Capacity-building is needed in the social sciences to ensure that research initiatives are built on a thorough understanding of this systems perspective and that research priority setting is undertaken in a truly 'needs driven' fashion. Capacity-building in this discipline is also needed to guide adaptive testing of technologies with farmers and consumers. This process of client consultation needs to take place as early as possible in the research process. Furthermore bearing in mind the importance of women in the production as well as postharvest systems of Uganda, it is strongly recommended that women with appropriate skills are actively encouraged to join postharvest research programs.

Fundamental technical research does not appear to be the only priority, particularly in the context of value-added processing of sweetpotato. Identification of market opportunities, choice of off-the-shelf technology and adaptation for local conditions would be also be (more) appropriate for exploiting the potential of sweetpotato. The National Postharvest Programme would benefit from capacity-building in these disciplines (essentially the social sciences), which could be achieved both by training to Ph.D. level and through collaborative research projects with international research institutions such as the International Potato Center (CIP) or the International Institute for Tropical Agriculture (IITA).

Partnerships. Also in the context of value-added processing of sweetpotato, there is a need to identify mechanisms by which technical options can be transferred within a framework of support, which can nurture the relevant entrepreneurial activities. This would include support in terms of marketing of products, market and quality information—tasks which are crucial to technology adoption, but an acknowledged weakness of research institutions and the traditional extension system. The research system needs to make additional linkages with the private sector broadly construed to exploit its ability to undertake these entrepreneurial tasks. An example of this type of linkage has been observed in the context of fruit processing in Uganda, where a commercial organization has been establishing networks of rural processors (Hall and Andrews, 1996). This organization trains processors and provides information on quality and fruit type demanded by the market, it then buys the processed products to supply identified markets. Technical backstopping is provided by the Ugandan National Postharvest Programme. The identification of such innovative mechanisms for the market integration of processed sweetpotato products, e.g. sweetpotato flour, is essential if the crop is to reach its potential to play a significant role in economic growth, poverty alleviation and the sustainability of rural livelihoods in Uganda.

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For additional information about potatoes, production prices and trade you may wish to consult the following websites:

WORLD
Food and Agriculture Organization of United Nations (FAO).
http: //www.fao.org/

Includes: Production, area, yield, foreign trade (fresh and processed), per capita utilization and consumption data for potato and sweetpotato from 1961 to 1998. For data on processed products enter the Statistical Database, then the Agriculture and Food Trade Database. Select 'Crops and Livestock. Primary and Processed' and then click on 'Item' – this will display a list of FAOSTAT codes for numerous fresh and processed commodities for use within the database.

http: //www.fao.org/inpho
Direct access to Information Network on Post-harvest Operations, or INPhO. This includes information on post-production data and resources, provides links with libraries and databases and offers communication services such as email conferences and question and answer facilities.

International Institute of Tropical Agriculture (IITA)
http: //www.cgiar.org/iita/inform/newslets.htm#PHS
A direct link to newsletters produced by

LATIN AMERICA
Secretaria de Agricultura, Ganadería, Pesca y Alimentación (**Argentina**).
http://siiap.sagyp.mecon.ar/home/agricult.htm

Includes: Monthly wholesale potato prices (1990 - 1998). Also area planted and harvested, production and yield. (1970/71 - 1997/98).

Instituto Nacional de Estadística de **Bolivia**
http:// www.ine.gov.bo/

Includes: Monthly potato prices from 1967 to May 1997.

Ministerio de Agricultura (**Colombia**)
http://www.dnp.gov.co/Publicac/UDA/Anuario/ANU95.htm

Includes; Potato production and area planted, 1987-95 ; wholesale potato prices in Bogota,1990-95.

Oficina de Estudios y Políticas Agrarias. Ministerio de Agricultura (**Chile**).
http://www.minagri.gob.cl/minagri/odepa/odepa.html

Includes: Production, area planted and yield for potato, 1989-97; Wholesale potato prices in Santiago,1997-98.

Consejo Nacional de Producción (**Costa Rica**).
http://agriforo.iica.ac.cr/cri/cnp/

Includes: Wholesale potato prices within CENADA, 1992-96.

Ministerio de Agricultura (**Perú**).
http://www.minag.gob.pe/

Includes: Production, area planted and yield for potato and sweetpotato. Also wholesale potato prices.

U.S.A
Potato Statistics
http://jan.mannlib.cornell.edu/data-sets/specialty/91011/

Includes: U.S. and state data on potato acreage, production, value, and use. Also includes U.S. data on prices, price spreads, and consumer and producer price indexes; stocks of fresh and processed potatoes; and trade in potatoes and potato products.

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