Micro-Scale Enterprise Approach to Sweetpotato and Potato Improvement Systems

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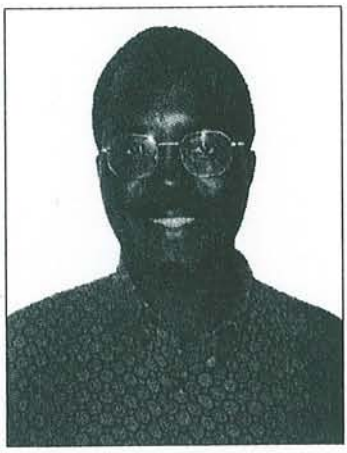

Sweetpotato Production and Harvesting

Sweetpotato (*Ipomoea batatas*) is an important subsistence food security crop grown on a small-scale in the densely populated, mid-elevation areas (1,200-2,000 m) of East Africa. It is a major staple food in Uganda, Rwanda, Burundi, and Eastern Democratic Republic of the Congo, and a secondary food crop in the grain-based food systems of Eastern and Central Africa. The crop is vegetatively propagated, requires low inputs for cultivation and produces modest yields of storage roots (Ewell 1993). The storage roots have a low dry matter content (30% of the root), with starch being the major component (Hagenimana 1994) (table 1). Like other root and tuber crops, fresh sweetpotato does not store well because of its high moisture content. The high moisture content also makes the crop bulky and therefore costly to transport over long distances. These attributes have made sweetpotato and other root and tuber crops essentially crops for rural consumption, in settings where the chain from the producer to consumer is short.

The sweetpotato storage roots are usually harvested a little at a time as needed over an extended period. Harvesting this way provides a flexible source of food for households (Smit and Ocitti p'Obwoya 1994).

Storage

In the fresh form, there is no long-term or even intermediate-term postharvest storage of sweetpotato roots in East Africa. The only kind of storage regularly practiced in the region is in-ground storage whereby farmers keep unharvested mature sweetpotatoes in the field until they are needed for consumption or sale. This practice, however, has problems because after maturation, pest infestations by sweetpotato weevils (*Cylas* spp.) become severe and cause production losses up to 50% (Ndamage 1988).

Sporadic use of rudimentary storage systems in traditional Kenyan communities (Karuri and Ojijo 1994) and storage consisting of underground pits in Uganda (Devereau and Bockett 1994), Malawi, and elsewhere in southern Africa (Woolfe 1992), and covering with grass, on platforms or in baskets (Onwueme 1982), have

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Table 1. Chemical characteristics of fresh sweetpotato roots (variety Tanzania).

Moisture content (%)	67
Dry matter content (%)	33
Starch content (%)	23.5
Dry starch extracted (g/100 g fresh root)	17.0
Total sugars content (%)	3.3
Total protein content (%)	1.65
Lipid content (%)	0.3
Ash content (%)	1.0
Total fiber (NSP[a] + lignin) (%)	3.0
Vitamins & other components (%)	0.3

a/ Non-starch polysaccharides.

been reported. Sprouting and spoilage are, however, common with these storage methods and the roots cannot be preserved well for a long time (Onwueme 1982).

Improvement Efforts

Sweetpotato has a broad genetic base, with tremendous variability (Woolfe 1992), and many characteristics, such as storability, processing quality, and postharvest resistance to pests and diseases differ from variety to variety (Scott et al. 1992; Gatumbi et al. 1992). However, most of the characteristics listed are still unknown for many varieties and therefore calls for continuous screening. Collaborators and CIP's breeding programs have been developing recommendations for appropriate cultivars and practices which improve root quality and extend fresh shelf-life, in the relative short-term. Efforts also include developing an understanding of the physiological mechanisms involved in the deterioration process to enable the development of improved cultivars in the long-term for East and Central Africa and other areas of the world. Since 1993, research on integrated pest management for sweetpotato weevils has been undertaken in Uganda as a collaboration between the National Agricultural Research Organization (NARO) sweetpotato program and CIP. An integrated crop management program which includes integrated pest management, variety improvement, fresh storage, management of storage pests in dried chips, and broadening the market base of the crop through processing into flour and other products would help farmers improve marketing and utilization of sweetpotato.

Potato Production

Forty percent of the total potato (*Solanum tuberosum*) production in sub-Saharan Africa is produced by countries belonging to the Regional Potato and Sweetpotato Improvement Program in Eastern and Central Africa (PRAPACE) (see table 2). The production is concentrated in densely populated highland areas. The reported average yields are very low, about 5.4 t/ha. As food, potato has less postharvest constraints compared with sweetpotato. The major problem lies with its production. However, accelerated adoption of production technology is often contingent on market outlets, consumer acceptability and storage capacity.

Current Utilization of Sweetpotato

Sweetpotato utilization is remarkably narrow in East Africa. In the fresh form, the crop is most often consumed boiled or roasted. Vines are fed to livestock, particularly in areas like central Kenya where small-scale dairying in zero grazing management systems, is well developed. The crop is also being used as starter feed and partial milk replacer for young calves (Orodho et al. 1995). The limited range of ways in which sweetpotato is utilized in the region seriously undermines the potential benefits of the crop to farmers and consumers. However, there are many products that can be made with

Table 2. Area, production, and yield of potato and sweetpotato for PRAPACE countries, 1995/97.

Country	Population (millions)	Potato Area (000 ha)	Potato Production (000 t)	Potato Yield (t/ha)	Sweetpotato Area (000 ha)	Sweetpotato Production (000 t)	Sweetpotato Yield (t/ha)
Burundi	6.2	14	42	3	111	673	6.1
D.R. Congo	46.8	7	40	5.9	109	409	3.8
Eritrea	3.3	5	40	8.2	0	0	-
Ethiopia	58.2	45	358	8	20	158	7.9
Kenya	27.8	75	205	2.7	74	633	8.5
Madagascar	15.4	49	278	5.7	84	469	5.6
Rwanda	5.4	25	98	3.9	150	1,050	7
Tanzania	30.8	36	242	6.8	250	386	1.5
Uganda	20.3	53	367	6.9	513	1,927	3.8
PRAPACE	214.2	308	1,669	5.4	1,311	5,706	4.4
SSA (1995)	n.a.	483	3,722	7.7	1,322	5,942	4.5

Source: FAO.

sweetpotato as a major ingredient. For example, Collins and Abdul-Aziz (1982) testing the effect of sweetpotato flour as an ingredient on quality of yeast-raised doughnuts, found the overall quality not significantly lowered by the addition of sweetpotato. Gakonyo (1993) and Omosa (1997) have shown that sweetpotato could, with a high degree of success, partially replace wheat flour in processing of baked and fried products. Odaga (1992) has shown that sweeter varieties of sweetpotato can save on sugar and wheat flour in baking.

In some parts of Uganda, farmers also harvest, chip, and sun dry the roots as a way to preserve and store the crop. The dried sweetpotatoes have become a very important staple during the long dry season due to the emergence and increasing severity of the African cassava mosaic virus (ACMV) (Hall 1995).

Current Utilization of Potato

Potato is a staple food and a cash crop in highland producing areas and a highly preferred food in fast growing urban areas. It provides on-farm and off-farm employment and critical income to poor households as most of the potatoes for the urban market are produced by small-scale farmers. Marketing channels have been developed between producing areas and urban areas primarily by small, independent traders and shippers.

The processing of potato into French fries and crisps, particularly for urban markets has provided employment opportunities in cities as chips are in high demand in restaurants and snack bars (Walingo et al. 1997). Processing reduces the bulkiness and perishability of the potato crop and consequently contributes to reducing marketing costs and consumer prices. However, the low processing quality of fresh potatoes is still a major constraint to processors. Other problems facing processors include the high capital investment required to purchase modern processing equipment, constant electrical power failures and water shortages that result in high losses.

Priority for Interdisciplinary Research

Few farmers in East Africa currently manage sweetpotato and potato for maximum yields. Research designed to increase productivity must be accompanied by research designed to increase market demand. In most parts of Africa, this means identifying opportunities for totally new uses for sweetpotato and potato, while enhancing traditional uses

Table 3. Major constraints to increasing production and productivity of potato and sweetpotato in PRAPACE countries.

Type	Constraint	Strategy
Socioeconomic & policy	Lack of policy for the production and supply of seed or planting material Lack of market studies and weak distribution systems Poor linkage between research, extension and private sector Lack of credit system and inability to purchase inputs	Policy and market studies Widening partnership Loan and credit policy
Seed/planting material	Lack of good quality seed/planting material of improved varieties and timely available	Informal farmer-based seed systems
Postharvest	Lack of storage & processing technology Opportunity for utilization & marketing not well developed Qualified human resource not available (all levels)	Selection of better varieties for postharvest characteristics Transfer of storage/processing technologies Product development, processing techniques and market studies Training
Biotic	Late blight, Bacterial wilt Viruses Weevils	Integrated management
Abiotic	Declining soil fertility and natural resource base Lack of early maturing, drought resistant, high dry matter & beta carotene contents materials	Varietal development Integrated nutrient management

and transferring proven technologies from one place to another, where conditions are similar. It also means dealing with production and post-production constraints, including marketing opportunities (see table 3). As a starting point appropriate product and processing technologies from Asia and Latin America can be tried and adapted to African conditions. The theoretical potential of sweetpotato and potato as a raw material can, however, be realized only through creative and flexible interdisciplinary research.

Objectives of Postharvest Research

The overall objective of CIP's postharvest research is to improve the welfare of the rural poor by diversification and expansion of sweetpotato and potato utilization. Working to attain this goal involves reducing processing costs, making more effective use of potato tubers and sweetpotato vines and roots, identifying new uses and markets, and facilitating the adoption of improved germplasm by identifying materials with superior postharvest traits. Specifically, CIP's postharvest research efforts aim to:

- Increase incomes and provide greater opportunities for women through the addition of value to the raw produce during primary processing. For example, obtaining desirable flour from sweetpotato roots and chips from potato, through technical and socioeconomic research.
- Enhance food security by taking advantage of the nutritional qualities of sweetpotatoes in fresh form.
- Analyze CIP's germplasm collection to identify clones with the most promising postharvest traits for starch, flour, and feed.

- Reduce rural poverty and improve food security by promoting a more efficient use of potato tubers and sweetpotato roots, and by using the vines and other by-products as animal feed.
- Strengthen and develop capabilities in potato and sweetpotato postharvest utilization through training.
- Build linkages with the private sector, policy makers, and other interested parties (e.g., rural development projects) for the purpose of generating policies and programs that support the diversification and expansion of sweetpotato utilization.

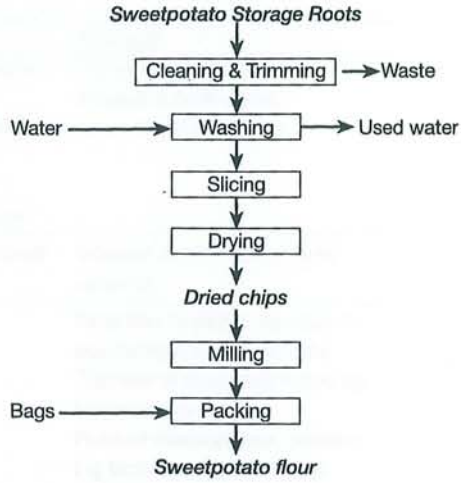

Fig. 1. Process flow diagram for producing dried sweetpotato chips and flour.

Strategy

In Africa, the fresh root market and on-farm consumption is still dominant. However, small-scale processing enterprises have been emerging in recent years that offer lessons for the future. Adding value to sweetpotatoes through processing, and using the vines and other by-products as animal feed, offer opportunities for income generation which can improve development for poor communities in many areas. Lessons can be learned from Asia where 85% of global sweetpotato production is concentrated and where shifts in utilization from fresh root consumption towards feed and processed products such as starch, chips and flour are in progress. It is important to focus postharvest utilization research on processed products like chips, crisps, starch and flour (see fig. 1) as well as animal feed from vines and roots. There must also be a continuous effort to develop new uses for the crop in the fresh form (Hagenimana et al. 1998a; Hagenimana et al. 1998b).

Ex-ante analyses of the potential markets for baked products (bread or buns, chapatis, and mandazis) with sweetpotato as an ingredient in Kampala and Lira, Uganda, indicated high acceptability and good competitiveness of the products, especially in small urban trading centers close to the sweetpotato production centers. Products containing cooked and mashed sweetpotato were exceptionally accepted by consumers who expressed a high level of willingness to pay the same prices for sweetpotato-based products as for similar products they have been buying. It was found that sweetpotato improves the taste, texture, freshness, appearance, sweetness and color of local foods such as buns, chapatis, and mandazis (Hagenimana and Owori 1996).

The nutritional value of sweetpotatoes (especially high levels of vitamin A) offer an added benefit to processed products. For example, studies have been conducted to assess the potential for improvement of the vitamin A status of people in western Kenya through the dissemination and promotion of the use of orange-fleshed sweetpotato varieties. The results of these studies suggest that the introduction of orange-fleshed sweetpotato varieties along with training

on processing, marketing and nutrition, could significantly contribute to alleviation of vitamin A deficiency in parts of Africa where sweetpotato is grown (Low et al. 1997; Hagenimana et al. 1998b; K'osambo et al. 1998).

Taking the above into consideration, CIP's postharvest research activities are guided by the following strategic principles:

- Focus on primary processing of potato and sweetpotato into value-added products such as chips, crisps, starch and flour.
- Focus on uses of potato and sweetpotato (including vines) as animal feed, especially for high producing animals such as pigs and dairy cattle.
- Use of product development methodology developed by CIP, CIAT and IITA. This methodology comprises opportunity identification, market and technical research, pilot enterprise feasibility and commercial expansion or replication of enterprises.
- Placing emphasis on small-scale technologies that are both efficient and produce quality products, or link small-scale producers to industrial-scale processors.
- Paying attention to basic research where necessary, to resolve problems or realize opportunities identified as important for target beneficiaries (e.g., starch functional properties as related to baking quality).
- Linking up with centers of expertise not available locally.
- Collaborating with the private sector, NGOs, national agricultural research systems and other international agricultural research centers involved with work in roots and tubers, where necessary, to achieve project objectives.

Technology Transfer

With respect to technology transfer, studies in Lira, Uganda, have shown that at least four steps are required to transfer an identified technology to users in food product and rural-based enterprises: market and consumer evaluation of the product, technical evaluation at the piloting scale, adjustment of the technology to the users' need, and invitation of enterprises to use the developed technologies through technical and financial training. The technical training should relate to potato and sweetpotato while the financial training should relate to loans and book keeping.

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