Micro-scale enterprise approach to sweetpotato and potato improvement systems

By

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Abstract

Adding value to sweetpotato and potato crops offers good potential for income generation and employment as well as for enhanced utilization of the crops. This provides a means to reduce poverty, improve food security and nutrition by developing small and micro-enterprises commercialising sweetpotato- and potato-based foods and feeds. Diversification in crop utilization patterns may also contribute to conservation of biodiversity. Several postharvest activities based on sweetpotato and potato are in progress in key east African countries; some of them have made progress in identification of strategies, methods, and technologies to improve the products, processes, and markets. Multidisciplinary and strategic research is being carried out collaboratively with users, local and national institutions, and regional networks. Further research should focus on piloting enterprises followed by commercial expansion/replication when and where results are justified.

Introduction

Sweetpotato production and harvesting

Sweetpotato (*Ipomoea batatas*) is an important subsistence crop in East Africa. It is a classic food security crop characterised by small-scale production in the densely populated, mid-elevation areas (1,200-2,000 m), low inputs, and modest yields (Ewell, 1993). It is vegetatively propagated and the storage roots have a low dry matter content (30% of the root) with starch being the major component (Hagenimana, 1994) (Table 1). The high moisture content attribute has important implications --poor storability and costly to transport over long distances. These aspects have made sweetpotato and most of other root and tuber crops essentially crops for rural consumption, in settings where the chain from the producer to consumer is short. Sweetpotato is a major staple food in Uganda, Rwanda, Burundi, and Eastern D.R. Congo, and a secondary food crop in the grain-based food systems of Eastern and Central Africa (Table 2). The sweetpotato storage roots are usually harvested piecemeal over an extended period, and this provides a flexible source of food for the households (Smit and Ocitti p'Obwoya, 1994).

In fresh form, there is in practice no long-or even intermediate-term postharvest storage of sweetpotato roots in East Africa. The only kind of storage regularly practised in the region is in-ground storage, by which farmers keep unharvested mature sweetpotatoes in the field until they are needed for consumption or sale. However, after maturation, pest infestations by sweetpotato weevil (*Cylas* spp.) become severe and cause production losses up to 50% (Ndamage, 1988). Since 1993, research on integrated pest management for sweetpotato weevils has taken place in Uganda, as a collaboration between NARO sweetpotato programme and CIP. An integrated crop management including IPM, variety improvement, fresh storage, management of storage pests in dried chips, and broadening the market of the crop by processing into flour and other processed products would help farmers to diversify the market and utilisation.

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

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, that depend on variety (Scott et al., 1992; Gatumbi et al., 1992). However, most of these characteristics are still unknown for many varieties and requires continuous screening. Collaborators and CIP's breeding programme have been developing recommendations for appropriate cultivars and practices which improve root quality and extend fresh shelf-life in the relative short-term, but also to develop an understanding of the physiological mechanisms involved in deterioration which will enable the development of improved cultivars in the long-term for East and Central Africa and other areas of the world. However, accelerated adoption of production technology is often contingent on market outlets, consumer acceptability and storage capacity.

Potato production and harvesting

40% of the total potato (*Solanum tuberosum*) production in sub-Saharan Africa is produced by PRAPACE countries (Table 2). The production is concentrated in densely populated highland areas, over 2,000 m. The reported average yields are very low, about 5.4 t/ha. Potato as a food has less postharvest constraints, the major problems reside in its production.

Current utilisation of sweetpotato crop

Sweetpotato utilisation is remarkably narrow in East Africa. The crop is most often consumed boiled or roasted in the fresh form. Vines are fed to livestock particularly in areas like central Kenya where small-scale dairying in zero grazing management systems is well developed. They are also being used as starter feed and partial milk replacer for young calves (Orodho et al., 1995). The limited range of ways and availability of adapted processing technologies in which sweetpotato is utilized in the region seriously undermine the potential benefits of the crop to farmers and consumers.

However, there are myriad of products that can be made using sweetpotato as a major ingredient (Ge et al., 1992). Collins and Abdul (1982) testing the effect of sweetpotato flour as an ingredient on quality of yeast-raised doughnuts found the overall quality not significantly lowered by addition of sweetpotato. Gakonyo (1993) and Omosa (1997) have shown that sweetpotato either in fresh grated, boiled and mashed, or flour form could, with high potential of success, partially replace wheat flour in processing of baked and fried products. A pilot sweetpotato bakery has been implemented in Burundi before the civil war (Berrios, 1994), and Odaga (1992) has shown how sweeter varieties can save sugar and wheat flour during the process of baking.

In some parts of Uganda (Bashaasha et al., 1995; Fowler and Stabrawa, 1993) and Tanzania (Kapinga et al., 1995) with a long, hot dry season, serious attacks by weevils limit the length of time that roots can be stored in the ground, and farmers harvest, chip, and sun dry the roots as a way to preserve and store the crop. In Uganda, as a result of a major change in the food system which has occurred with increasing severity since the emergence of African Cassava Mosaic Virus (ACMV) in 1986, the dried sweetpotatoes have become a very important staple during the long dry season (Hall, 1995). They ensure food security not only for those households holding stocks but also for the community as a whole because those without food reserves work for those who have them, in exchange for dried sweetpotato. *A. fasciculatus* has been identified as the major loss causing organisms of dried sweetpotato chips (Agona, 1995). Management methods to reduce its pest status and damage levels including parboiling of roots prior to slicing and drying, storage of dried chips in sealed containers, varietal trials, salting prior drying and other desinfestation methods focused on solar energy are being studied at Kawanda Postharvest Programme, Uganda.

Current utilisation 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 potato for the urban market is produced by small-scale farmers. Marketing channels have been

developed between producing areas and urban areas primarily by small, independent traders and shippers.

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

Priority for interdisciplinary research

Few farmers in East Africa currently manage sweetpotato and potato for maximum yields. Research designed to increase productivity through improved varieties and planting material, pest and disease control, etc. must be accompanied by research designed to increase market demand (Table 3). In most parts of Africa, this means identifying opportunities for totally new uses for sweetpotato and potato, as well as enhancing traditional uses and transferring proven technologies from one place to another where conditions are similar. Experience with products and process technologies from Asia and Latin America can serve as a starting point for adaptation to conditions in Africa, but theoretical potential of sweetpotato and potato as a raw material can be realized if creative and flexible interdisciplinary research with focus on identification of marketing opportunities necessary to adapt new ideas to local tastes, technologies, and economic conditions.

General objectives of postharvest research

The overall objective is to improve the welfare of the rural poor by diversification and expansion of sweetpotato and potato utilization. This goal will be achieved by reducing processing costs and improving processes, making more effective use of potato tubers and sweetpotato vines and roots, identifying new uses and product markets, and facilitating the adoption of improved germplasm by identifying materials with superior postharvest traits –all contributing to increased rural employment and value added, reduced rural poverty, greater opportunites for women and enhanced food security.

Specific objectives

1. Increase incomes and provide greater opportunities for women by fostering added value during primary processing (e.g. flour of sweetpotato roots, chips of potato) through technical and socio-economic research.
2. Enhance food security by taking advantage of sweetpotatoes nutritional qualities in fresh form.
3. Analyze CIP's germplasm collection to identify clones with the most promising postharvest traits for starch, flour, and feed.
4. Reduce rural poverty and improve food security by catalyzing more efficient use of potato tubers, sweetpotato roots, vines, and by-products as animal feed.
5. Strenghten local research and development capabilities in potato and sweetpotato postharvest utilization through training, in particular training through research.

6. Build linkages to the private sector, policy makers, and other interested parties (e.g., rural development projects) for the purpose of generating the policies and programs supportive of diversifying and expanding sweetpotato utilization.

Strategy

The overall strategy for this project is grounded in the trends and associated opportunities observed over the last decade. In Asia, where 85% of global sweetpotato production is concentrated, fresh root consumption is declining as incomes increase and societies urbanize. Shifts in utilization, towards feed and processing (starch and chips/flour) are in progress, especially in China. Besides being produced by small farmers in poor regions of Asia, sweetpotato processing and feed is predominantly an activity carried out at a small-scale using traditional technologies and knowledge. Adding value to sweetpotatoes through processing and feeding animals offers opportunities for income generation and livelihood development for poor communities in many areas.

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. The nutritional value of sweetpotatoes (especially vitamin A) provides an added benefit here. The growing demand for dairy products in urban areas offers opportunities for expanding use of sweetpotato as a fodder supplement. Potato chips and crisps are foods of high demand in fast growing urban areas.

Characterization of the range of key quality factors and functional properties found in sweetpotato and potato germplasm collections held by CIP and national programs and that can be exploited through processing is a critical component of any effort to improve the quality of processed products/raw materials. Outputs from the characterization of germplasm for postharvest characteristics will be used in breeding programs.

Given these trends and opportunities, sweetpotato and potato postharvest utilization research will focus on chips and crisps, starch, flour, feed (vines and roots), and new uses for sweetpotato in fresh form in those select number of countries, and regions within countries, where the relative abundance of sweetpotato/potato and the concentration of rural and urban poverty enhance the potential for impact.

Strategic principles

Taking into account the above, posthavest activities will target the resources available using the following principles:

- Focus on products/utilization of widespread application especially primary processing (chips, crisps, starch, flour) and animal feed (principally pigs and dairy cattle) uses.
- Product development methodology will be used, comprising: opportunity identification, market and technical research, pilot enterprise feasibility, and commercial expansion/replication of enterprises. As developed/used by CIP/CIAT/IITA and other collaborating R and D institutes in Asia or Latin America.
- Emphasis on small-scale technologies that are both efficient and produce quality products; or, linkages of small producers to industrial-scale processing.
- Attention to enterprise development issues that affect the commercial application of utilization-related technologies, and hence project impact.

- A food systems focus, taking crop (raw material) supply (production) and product marketing into account, as well as, where relevant:

  Other roots and tubers (e.g., cassava, sorghum and millet in Uganda, when combined with sweetpotato for *atapa* processing).

  Other system components (e.g., feed supplements, where their use can improve sweetpotato feed efficiency).
- Attention to basic research as necessary to resolve problems or realize opportunities identified as important for target beneficiaries (e.g., starch functional properties, as related to baking quality).
- User orientation, including processors and consumers, as well as sweetpotato/potato producers, in specific high priority locations where impact is sought and where technologies and enterprises can be piloted.
- Links to centers of expertise not found in house as necessary.
- Collaboration with private sector, NGO's, NARS, etc., as relevant and to meet project objectives.
- Complementarily with other roots and tuber IARCs: CIAT and IITA collaboration where relevant.

Selected outputs

Assessment of existing processing systems and identification of opportunities for the development sweetpotato products.

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 the high acceptability and good competitiveness of the products, especially in small urban trading centers close to the sweetpotato production. Products containing cooked and mashed sweetpotato were exceptionally highly accepted by consumers who expressed a high level of willingness to pay the same price for sweetpotato products as for similar products they have had been buying (Table 4). It was found that sweetpotato improves the taste, texture, freshness, appearance, sweetness and color of buns, chapatis, and mandazis. Detailed report has been compiled by Hagenimana and Owori (1996). Similar analysis has been done on potato (Walingo et al. 1997).

Further to the above analyses, implementation studies on how to transfer the identified technology to users were conducted in Lira, Uganda. It was found that at least four steps were required in food product and rural based enterprises: 1) market and consumer evaluation of the product, 2) technical evaluation at the piloting scale, 3) adjustment of the technology to the users' need, and 4) invitation of enterprises to use the developed technologies through technical (sweetpotato related) and financial (loans and book keeping) training.

Figure 1 shows the process of producing dried sweetpotato slices and flour used in baking. The diagram will assist the researcher, farmer or processor to identify and plan for the needs in raw material and other utilities, equipment, and time (for more details see Hagenimana et al., 1998a; Hagenimana et al., 1998b).

Reducing vitamin A deficiency through introduction of orange-fleshed sweetpotatoes

A study designed in Figure 2 was conducted to assess the potential for improvement of the vitamin A status of people in western Kenya through the dissemination and promotion of orange-fleshed sweetpotato varieties. Highly yielding orange-fleshed sweetpotato varieties were given to members of 20 women's groups from two divisions in South Nyanza Province of western Kenya, and members were educated about vitamin A. Half of the groups were trained in methods of sweetpotato processing and utilisation (Figure 3). Changes in vitamin A consumption patterns among children were evaluated using the HKI food frequency method. Pre-intervention baseline assessment from 15 communities in which the women's groups were located showed that vitamin A consumption was quite low, with an average HKI score of 4.0, well below the cut off of 6.0 (Figure 4). Results of this assessment suggested that orange-fleshed sweetpotatoes would be an inexpensive source of dietary vitamin A (Figure 5) that could be produced year-round. Of all the available plant sources of vitamin A, orange-fleshed sweetpotatoes would also be the best source of calories. Post-intervention HKI scores, earnings from sales of orange-fleshed sweetpotatoes and other income variables were compared for the women's groups. Groups that had received intervention components including processing and sweetpotato utilization had significantly higher HKI scores, and a better knowledge of food sources of vitamin A than groups that did not receive training. Our results suggest that 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 (for more details see Low et al., 1997; Hagenimana et al., 1998b, K'osambo et al., 1998)

Dissemination of technical sweetpotato and potato research information

CIP's postharvest activities has been supporting students and young scientists and technicians in the initial research on sweetpotato and potato postharvest issues. Working groups on postharvest research is emerging, and a body of locally generated scientific literature has begun to be developed to provide the foundation for longer term efforts aimed at addressing sweetpotato and potato postharvest problems and opportunities.

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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 managements
Abiotic	• Decline soil fertility and natural resource base • Lack of early maturing, drought resistant, high dry matter & β–carotene contents materials	• Varietal development • Integrated nutrient management

Table 2. Statistics of Potato and Sweetpotato for PRAPACE countries, 1995-97

		Potato			Sweetpotato		
COUNTRY	**POPULATION** (000)	**AREA** (000 HA)	**PRODUCTION** (000 T)	**YIELD** (T/HA)	**AREA** (000 HA)	**PRODUCTION** (000 T)	**YIELD** (T/HA)
Burundi	6,221	14.0	42.0	3.0	111.0	673.0	6.1
D.R. Congo	46,812	6.7	39.7	5.9	109.0	409.1	3.8
Eritrea	3,280	4.9	40.0	8.2	0	0	-
Ethiopia	58,243	45.0	358.3	8.0	20.0	158.3	7.9
Kenya	27,800	75.0	205.0	2.7	74.3	633.3	8.5
Madagascar	15,353	48.9	278.0	5.7	84.0	469.0	5.6
Rwanda	5,397	25.0	97.5	3.9	150.0	1,050.0	7.0
Tanzania	30,800	35.5	241.7	6.8	250.0	386.2	1.5
Uganda	20,256	53.0	367.0	6.9	513.0	1,927.0	3.8
PRAPACE	**214,162**	**308.0**	**1,669.1**	**5.4**	**1,311.3**	**5,705.9**	**4.4**
SSA (1995)	nd	483.0	3,722.0	7.7	1.322.0	5,942.0	4.5

Source: FAO Internet Agrostat Database

Table 4. Comparative gross margins of sweetpotato products and wheat flour products, Lira, Uganda.

Product	Net revenue per product (US$)		
	Wheat flour	Sweetpotato cooked & mashed	Sweetpotato flour
Chapatis (1 piece)	0.032	0.045	0.047
Mandazis (1 piece)	0.014	0.023	0.024
Buns (1 piece)	0.007	0.014	0.015
Bread (1 loaf of 500 g)	0.058	0.065	0.069

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 fibre (NSP + lignin) (%)	3.0
Vitamins & other components (%)	0.3

NSP-Non Starch Polysaccharides

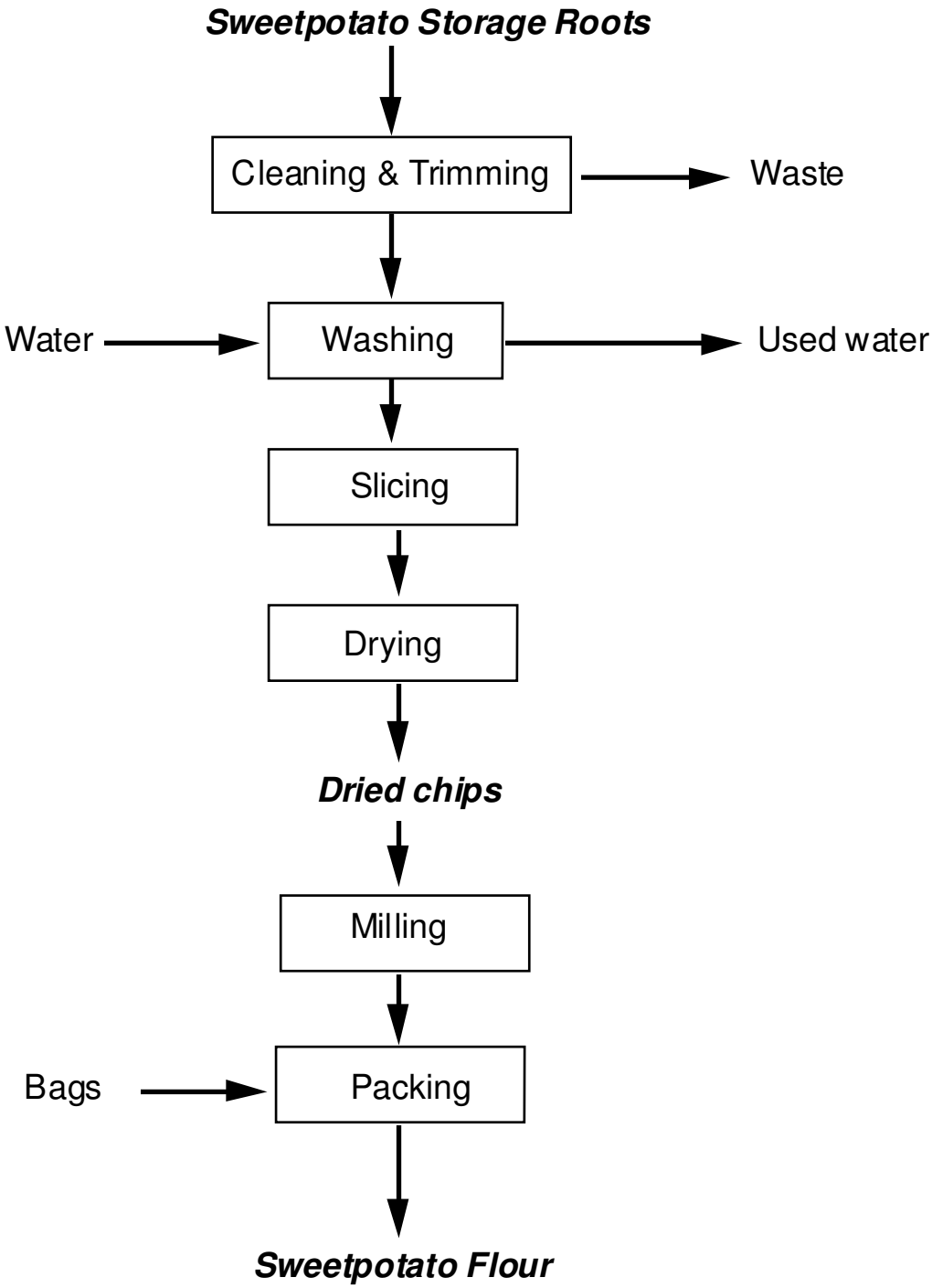

Figure 1. Process flow diagram for producing dried sweetpotato chips and flour