Sweetpotato final project report (2003/4-2004/5)

MAK-FST coalition partner

Submitted to Managing Partner
Regional network for potato and sweetpotato programmed in East and Central Africa (PRAPACE)

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1 Background

Makerere University – Department of Food Science and Technology (MAK-FST) as one of the partners on the Sweetpotato (SP) coalition project performed the following roles:

i) Quality assessment of SP products of the roots and their respective products
ii) Pass on knowledge (nutritional value of products) to the target groups by training farmer group leaders, extension agents, school representatives and quality control assessors

Quality assessment of SP products was based on both physicochemical and microbiological laboratory analyses. Dry matter, provitamin A (*beta-carotene*) levels, starch, sugar profile and the yeast and mold count were the main parameters selected as quality criteria for SP products for either the local or export markets. Additional physicochemical parameters included determining the approximate composition of sweetpotato composite flours.

The report summaries research studies and project activities where MAK-FST participated jointly with other coalition partners, to achieve the designated roles. Also included are other SP related activities not directly accruing from the SP coalition project work.

1.1 Project outputs addressed by Makerere University, Department of Food Science and Technology

The project sought to sustainably reduce post harvest losses of sweet potato through increased incomes for the rural farmer and processor, from sweet potato and its products in central Uganda. Four outputs addressing the purpose were:

Output 1:
Rural sweetpotato farmers in central Uganda linked to local export markets
Output 2:
Post harvest capacity of rural sweetpotato farmers and processors in Central Uganda enhanced
Output 3
Sweet potato based income-generating opportunities created for resource poor youth and women
Output 4:
An institutional mechanism that empowers poor farmers and rural processors to participate in SP technology and knowledge innovation systems (TKIS) developed

Activities that MAK-FST performed were embedded in Outputs 1, 2 and 4.

2 Methodology

Most project activities done by MAK-FST were laboratory based. Sweetpotato samples received from various coalition partners accrued from research studies and experiments designed as shown in Table 1. All analyses were performed in the Department laboratory facilities except for the sugar profile and beta-carotene content which were performed in n external laboratory equipped with high –pressure liquid chromatography. Analytical grade reagents were used for all the physicochemical and microbiological analyses.

Table 1 Research studies and respective sweetpotato varieties procured

Study	District	Lead farmer & farmer group name	Variety	Maturity age (months)	Other Implementing partners
1	Luweero		Kala; Ejumula; SPK004 (Kakemega)	3	HORTEXA PRAPACE
2 and 3	Luweero	Seytyabula Rajab – [Sikyomu]	Sudan local; Kala; Ejumula Naspot 1; Naspot 2; SPK004	5	FOSRI
		Gingo - [Kamu]	Dimbuka; Ejumula; Naspot 1 Naspot 2; SPK004	5	
	Mpigi	Semanda - [Nindye Self Help]	Naspot 1; Semanda	4	
		Jaliya Namusoke - [Nindye Self Help]	Naspot 1	3	
		Mary Senyonga - [Tulina Essubi women's group]	Naspot 1; New Kawogo	4 5	
		Fiona Nabanda - [Tulina Essubi women's group]	New Kawogo	6	
		Vincent Lwanyaga - [Kikoota]	Naspot 1	4	
	Kiboga	David Kyatule - [Tukola Community Based Organization]	Naspot 1; New Kawogo SPK004	4.5	
		Ronald Musisi - [Kinakulya Kakuuto]	Naspot 1; Kala; SPK004	3.5	
4	Kiboga		Naspot 1	3.5	KARI

1: Sea freight simulation study
2: Physicochemical parameters of sweetpotato in project districts
3: Effect of clamp and pit storage methods (technologies) on selected physicochemical parameters of sweetpotato
4: Six-month shelf study of sweetpotato composite flours containing a cereal and legume

3 Summary of research studies and project activities conducted by other coalition partners and MAK-FST

3.1 Output 1

3.1.1 Sea freight simulation study

There is still high demand for sweetpotato (SP) roots on the European market, most of which is obtained from the Caribbean by sea freight. African SP is air freighted, as is the case for Uganda, because the costs of air freighting SP are extremely high since it is a low value export crop, and usually used as filler in the freight containers for the high value crops. A sea shipment simulation study was therefore conducted to assess the performance of SP under simulated sea-freight conditions and estimate the cost of sea freighting SP. The study was implemented by CIP, PRAPACE, an International shipping company SDV-Transami Uganda (LTD), HORTEXA, and MAK-FST coalition partners. Eighteen metric tons of SP were procured from HORTEXA and BUCADEF farmers, packaged in 10 kg waxed cartons, and packed in a refrigerated freight container, maintained at 14°C and 90% relative humidity, for 50 days. Sweetpotato varieties used for the study were the yellow to orange fleshed varieties: *Kakamega (SPK004), Ejumula, Kala,* and the off-white to white-fleshed varieties: *Naspot 1, Naspot 2, #93/29, Kasujja, New Kawogo, Nakakande and Jowelia*. The first experiment involved monitoring the morphological and physiological appearance, and performing a sensory evaluation of the off-white to white-fleshed varieties. The second experiment involved monitoring the change in dry matter, weights of roots and beta-carotene content of the yellow to orange-fleshed varieties. Sweetpotato that had been handled properly appeared visually fresh compared to those that had not been well handled, which visibly deteriorated. Kakamega variety stored best of all varieties and showed no significant weight loss, rotting and sprouting. Varieties that were cured, that is dehaulmed two weeks prior to harvest showed low levels of weight loss and soft rotting, Pythium. Sweetpotato that had not been cured showed three types of rotting restricted to the tips of the root. Ejumula SP variety deteriorated the most compared to all varieties that were investigated. Of all varieties, #93/29 showed some sprouting. Variety #93/29 produced considerable amounts of latex and showed no damage on the tips, which was attributed a better healing phenomenon compared to other varieties that hardly exuded latex. Generally dehaulming two weeks prior to harvest tremendously improved SP quality. The African panelists ranked the steamed SP as fair to good while the European panelist rated the SP as good to very good. Beta-carotene was highest for Ejumula variety (4.8-8 mg / 100 g), Kakamega (4.5-5.5 mg / 100 g) and Kala (<1.0 mg/100 g) on dry solids basis. Percent loss of dry matter, weight of roots and beta-carotene content depended on variety and individual roots per variety. Percent root weight loss was not more than 12%. Beta-carotene percent losses were generally not more than 30%, with Kakamega variety showing the lowest percent loss (< 20%). An increment in dry mater suggested SP had absorbed moisture presumably due to the humid environment (90% relative humidity). The returns for a farmer producing SP for the export market was estimated at US$ 489-2500 per ha of the improved varieties, much higher for the domestic market at US$ 54 -1194 per ha. Sea freighting SP was estimated to fetch US$ 394-6,902 probably selling at a competitive price of US$ 1.01 per hectare. However, this would require the exporter to sell at US$ 2.25 per hectare in order to earn US$ 1,612-8,523. The study indicated that export of SP by sea is technically and economically feasible.

3.2 Output 2

3.2.1 Selected physicochemical parameters of sweetpotato varieties grown in the target districts

A number of improved sweetpotato (SP) varieties have been introduced by SP breeders of NAARI and CIP in the East African region. These varieties have been reported to possess improved agronomic characteristics and high beta-carotene content. The objective of the study was to determine selected physicochemical parameters of these improved varieties from the target districts of the project. Typically Luweero district grows the yellow to orange-fleshed varieties. While Kiboga and Mpigi grow mainly the white-fleshed varieties. Naspot 1 and Soroti, cream to yellow fleshed varieties were the only high beta-carotene varieties grown in Kiboga and Mpigi. Dry matter, starch and beta-carotene contents, and sugar profile of SP were determined. All SP varieties from the 3 districts contained dry matter levels of more than 30%, with Mpigi varieties (*Naspot 2, New Kawogo and Semanda*) and containing highest dry matter of up to 40%. Sugar profile of SP showed they contain sucrose, fructose and glucose. Maltose was found as trace levels in one variety. Total sugar levels of SP varieties was 1.5 g/ 100 g for the white fleshed varieties (*New Kawogo, Semanda*) and 0.5 g / 100g for the yellow fleshed (*Naspot 1, Soroti*). Variations in starch contents were obtained for SP in the 3 districts. A few varieties contained 40% starch (dry basis), while the majority contained 50-70%. New Kawogo and Semanda varieties from Mpigi district were recorded to contain highest starch contents (90%, dry basis). Variations in beta-carotene content were noted. The yellow to orange-fleshed varieties that are grown in Luweero district had the highest beta-carotene levels, on dry basis, Ejumula ($\approx$100 mg/ 100 g) containing the highest, followed by SPK004 ($\approx$60 mg / 100 g), Soroti and Naspot 1 ($\approx$2 mg / 100 g). Low or trace beta-carotene contents of < 0.1 mg / 100 g were measured for the white-fleshed varieties (New Kawogo and Semanda varieties) that were obtained mainly Mpigi district. Although, it was not possible to determine statistical differences in physicochemical parameters of SP, since farmers from the different districts have not adopted the same varieties, the data collected gives an indication of the levels of these parameters that were not different from SP grown in the E. African region or other regions.

3.2.2 Changes in selected physicochemical parameters of sweetpotato roots under the long-term storage technologies (clamp and pit)

Lack of farmers' knowledge on storage technologies for sweetpotato (SP) was identified as a factor leading to high post harvest losses. The objective of this part of the study was to introduce the clamp and pit storage technologies to small-scale farmers of Luweero and Mpigi districts, as a way of improving their livelihood. Based on a participatory approach, farmers harvested and cured SP from their fields, and stored the SP in clamp and pit stores that they constructed on designated farmer fields that served as demonstration cites. Dry matter, beta-carotene, reducing and sucrose sugars were the physicochemical parameters monitored over a 60 day period in Mpigi and 90 days in Luweero district. Improved SP varieties: *Ejumula, Naspot 1, Naspot 2, New Kawogo, Semanda and SPK004* were used for the storage study. Dry matter contents of SP were exceptionally high, particularly for roots from Mpigi district, with Semanda variety having the highest dry matter (41%). High beta-carotene concentrations were recorded for the orange-fleshed varieties, SPK004 and Ejumula, 68 and 125 mg/100 g dry basis, respectively. Total sugar contents of the roots were generally low (1.6-3.7 g/100 g), with exception of Naspot 2 (5.7 g/100 g). Changes in dry matter, beta-carotene and sugar contents of SP depended on location, and differed for both districts. No consistent trends in dry matter, reducing and sucrose contents were noted for SP in Luweero district. A pseudo decrease in sugar contents noted for Mpigi SP roots in both the clamp and pit stores, was due to a decrease in dry matter for these SP. Although beta-carotene generally decreased with storage time for SP roots in both types of stores of Luweero and Mpigi districts, the residual beta-carotene (2.6-3.4 mg/100 g, dry basis) in the orange-fleshed SP varieties could provide sufficient recommended daily allowance of vitamin A. Although the clamp and pit stores were found to have an effect on selected physicochemical parameters, monitoring temperature, relative humidity and atmospheric compositions of the long-terms stores is needed to assess changes on specific varieties, due to differences in respiratory patterns of SP varieties.

3.2.3 Training of Trainees on nutritional value of sweetpotato products

Imparting sweetpotato post harvest knowledge and skills was a major activity milestone of the project to enhance the post harvest capacity of the rural farmers and processors. Selected trainees of the project viz. farmer group leaders, extension workers, secondary school head teachers were given various skills and knowledge on aspects of sweetpotato post harvest technologies. The objective of the training offered by MAK-FST was to pass on knowledge on nutritional value of SP products (roots and value added products), effects of post harvest handling and processing on the nutritional value of SP, and criteria for selected physicochemical parameters to assess the quality of SP products. Twenty-three trainees were trained and work plans established for the respective category of trainees to further train other project beneficiaries.

3.2.4 Shelf life study of sweetpotato composite flours

Drying of sweetpotato (SP) to chips is one of the feasible and cheap SP post harvest technologies for SP rural farmers. This is a traditional technology in Eastern Uganda and has been adopted to diversify products from sweetpotato. Milling of dry SP chips to flour can be incorporated into a range of processed products and has been identified as a potential product for the local market. Sweetpotato composite flour mixtures constituted of a cereal and legume have been developed by KARI and introduced to potential rural processors and market tested for their acceptability. The same SP composite flours were subjected to six-month storage at ambient conditions (23-27°C) and selected physicochemical and microbiological parameters monitored. Moisture and reducing sugar contents, and yeast and mould counts of the composite flours were determined monthly, used as criteria to assess spoilage or loss in quality of the products. All flour ratios contained moisture levels of less than 13 %, which is the recommended moisture level of dry food products. Reducing sugar levels were lowest for flour ratio 6 and highest for flour ratio 2. Low yeast and mould count (< 4.5 cfu/g) was noted for all flours, with flour ratio 5 having negligible yeast and mould counts. A gradual increase in the moisture content of all SP flours with moisture levels peaking after 4 months of storage, except for flour ratio 5. Despite the increment moisture content of all the flours was not more than 13%, implying the quality of the flour was relatively stable, indicating that spoilage activities would occur at very low rates. A similar trend in reducing sugar content to moisture levels was noted for all flours, with reducing sugar content peaking after 4 months, except flour ratio 1 where reducing sugars were highest at the 3rd month. By the end of the storage period flour ratios 2 and 4 had the highest reducing sugar contents of 19 and 26 g/ 100 g dry basis, respectively.

High initial reducing sugar contents of these flour ratios 2 and 4, at zero month possibly explains their high sugar at end of storage. High reducing sugar of these flours suggests they maybe prone to spoilage and hence a shorter shelf life compared to the rest of the SP composite flours. The yeast and mould count for all flours was below 1,000 colony forming units (cfu) per g of flour, except flour ratio 6 that had a count of almost 1,800 cfu/g at the 3rd month of storage for the 2nd batch of flours analysed. It was expected that the increased level of moisture and reducing content would lead to proliferation of yeast and moulds. Flour ratio 5 had negligible levels of yeast and mould through out the storage period. Generally since moisture content of flours was below 12%, it can be concluded the flours did not undergone spoilage and were fit for consumption.

3.3 Output 4

Activity milestones pertaining to establishing a sustained institutional frame work of coalition partners involved participating in setting up rules of operation as a coalition and taking inventory of post harvest structures in demonstrations cites of schools and farmer cites. Also farmer and university linkages have been strengthened due to the project activities and studies jointly done with the farmers and other partners.

4 Other achievements related to Sweetpotato Coalition project

MAK-FST participated in two sweetpotato related activities that were not directly linked to the SP coalition but involved disseminating data and information from SP coalition project.

A poster presentation of coalition activities was presented at the 13th Symposium of the International Society for Tropical Root Crops held on 9 to 15th November 2003 in Arusha, Tanzania. The poster was jointly prepared with coalition partners and entitled *"Improving the livelihoods of small-scale Sweet potato farmers in Central Uganda through a crop post harvest-based innovation system"* (abstract of poster in Appendix 5.1).

Secondly, a paper has been submitted for publication in the Uganda Journal of agricultural Sciences entitled the "*effects of long-term storage technologies on the chemical compositional of sweetpotato*" and was presented at the International NARO conference, 1-4th September 2004. (Abstract of paper in Appendix 5.2)

5 Appendix

5.1 Abstract for Coalition poster presented at the 13th ISTRC conference in Arusha

Improving the livelihoods of small-scale Sweet potato farmers in Central Uganda through a crop post harvest-based innovation system

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Abstract

Limited market access and high post harvest losses of sweetpotato (SP) are the major factors of poverty status of the rural small-scale farmers in Central Uganda.. To break this poverty cycle adoption of interventions that promote post harvest technologies by farmers with the aim of improved access to markets has been initiated through an institutional framework consisting of several partners. The partners include farmers, Extension agents (BUCADEF & HORTEXA), school representatives (BRIBTE), national research institutions, regional networks (PRAPACE, FOODNET) and the International Potato Centre (CIP). Selected post harvest technologies have been introduced to farmer groups in three target districts of Central Uganda. The institutional mechanisms of transferring technologies to farmers involve research institutions providing the technologies and a backstopping role to farmers, participatory characterization of SP products for existing and new markets (local and export), and selection and adoption of SP technologies by farmers. Farmers have been trained and shown the specific market characteristics for SP roots and where new varieties such as Ejumula and SPK004 have been assessed as potential products for the export market. A shipment simulation study was conducted to understand changes in nutritional compositional and morphological attributes of the SP roots during the shipment period. Farmers have selected storage methods that they can construct and sustain. Farmers have been involved in sensory evaluation exercises to select SP roots that possess attributes the local market demands. The coalition partners are ensuring that the target farmers are gradually empowered through acquiring knowledge and demanding for technologies.

Keywords: Farmers, Sweet potato, Post harvest, Markets, Technologies

5.2 Abstract for paper presented at the NARO conference, Entebbe 1-4 September, 2004, a publication in the Uganda Journal of Agricultural Sciences

LONG-TERM STORAGE OF SWEETPOTATO BY SMALL-SCALE FARMERS THROUGH IMPROVED POST HARVEST TECHNOLOGIES

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Abstract
Sweetpotato (SP) small-scale farmers of Luweero and Mpigi districts were introduced to improved long-term storage methods (pit and clamp) as a way of improving their livelihood. Based on a participatory approach, farmers were involved in a storage study where dry matter, beta-carotene and sugar content parameters were monitored over a 60 day period in Mpigi and 90 days in Luweero district. Pit and clamp stores were constructed by farmers in selected sites of each district. Improved SP varieties (Ejumula, Naspot 1, Naspot 2, New Kawogo, Semanda and SPK004) were used for the storage study. Dry matter contents of SP were exceptionally high, particularly for roots from Mpigi district, with Semanda variety having the highest dry matter (41%). High beta-carotene concentrations were recorded for the orange-fleshed varieties, SPK004 and Ejumula, 68 and 125 mg/100 g, respectively. Total sugar contents of the roots were generally low (1.6-3.7 g/100 g), with exception of Naspot 2 (5.7 g/100 g). Changes in dry matter, beta-carotene and sugar contents of SP depended on location, and differed for both districts. No consistent trends in dry matter, reducing and sucrose contents were noted for SP in Luweero district. The decrease in sugar contents noted for Mpigi SP was due to a general decrease in dry matter for these SP. Although beta-carotene generally decreased with storage period for SP in both districts, the residual beta-carotene (2.6-3.4 mg/100 g) in the orange-fleshed SP varieties could be sufficient as the recommended daily allowance intake of vitamin A. Monitoring temperature, relative humidity and atmospheric compositions of the long-terms stores is needed to assess the performance of individual SP varieties.

Key words: Long-term storage, small-scale farmer, sweetpotato, post harvest technologies