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POSTHARVEST LOSS ASSESSMENT OF ORANGE-FLESHED SWEET POTATOES IN RWANDA

JULY 2018



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FEED THE FUTURE INNOVATION LAB FOR HORTICULTURE

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COVER PHOTO:

Orange-fleshed sweet potato collection site. Photo by Solange Musanase for the Horticulture Innovation Lab.



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Agribusiness Associates

Started by Mr. Gurbinder Singh Gill, Agribusiness Associates is an international development consulting firm focusing on overcoming the biggest challenges in the agricultural sector. The firm has special expertise in offering comprehensive solutions to the agribusiness sector for enterprise development. ABA has worked in public-private partnerships, seed industry, technology adoption, capacity building and providing strategic advisory services.

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ABBREVIATIONS & ACRONYMS

CIP	International Potato Center
CSAM	Commodity Systems Assessment Methodology
HACCP	Hazard analysis critical control points
OFSP	Orange Fleshed Sweet Potato
PEF	The Postharvest Education Foundation
PHI	Postharvest intervals
PTSC	Postharvest Training & Services Center
RAB	Rwanda Agriculture Board
RBS	Rwanda Standards Board
RPC	Returnable Plastic Crate
SSC	Solid soluble content
WFLO	World Food Logistics Organization
ZECC	Zero Energy Cool Chamber

1. EXECUTIVE SUMMARY

Orange Fleshed Sweet Potato (OFSP) is a relatively new crop for Rwanda with two decades of significant support from the NGO community. The crop is primarily grown as a livelihoods and food security crop with a strong nutritional component. The main challenges for OFSP include uncertain market demand and uncertain supply issues for processors, both of which are linked: due to the lack of a local fresh market, farmers may be reluctant to engage in OFSP production, while processors cannot engage in processing without assured supply.

The study found that at the farm level, 22.5% of the produce had defects, 3.5% was decayed and 35% had mechanical damage. On average, 10% of the produce was sorted out and consumed at home or used as animal feed (depending on the level of damage). At the wholesale level, 15% of the produce had defects, 5% had decay and 20% had mechanical damage. At the wholesale level, the team observed only one case of 5% produce being sorted out. To understand the postharvest losses in orange fleshed sweet potato, the project conducted Value Chain Analysis and Commodity Systems Assessment Methodology (CSAM). The following graphic illustrates the losses.

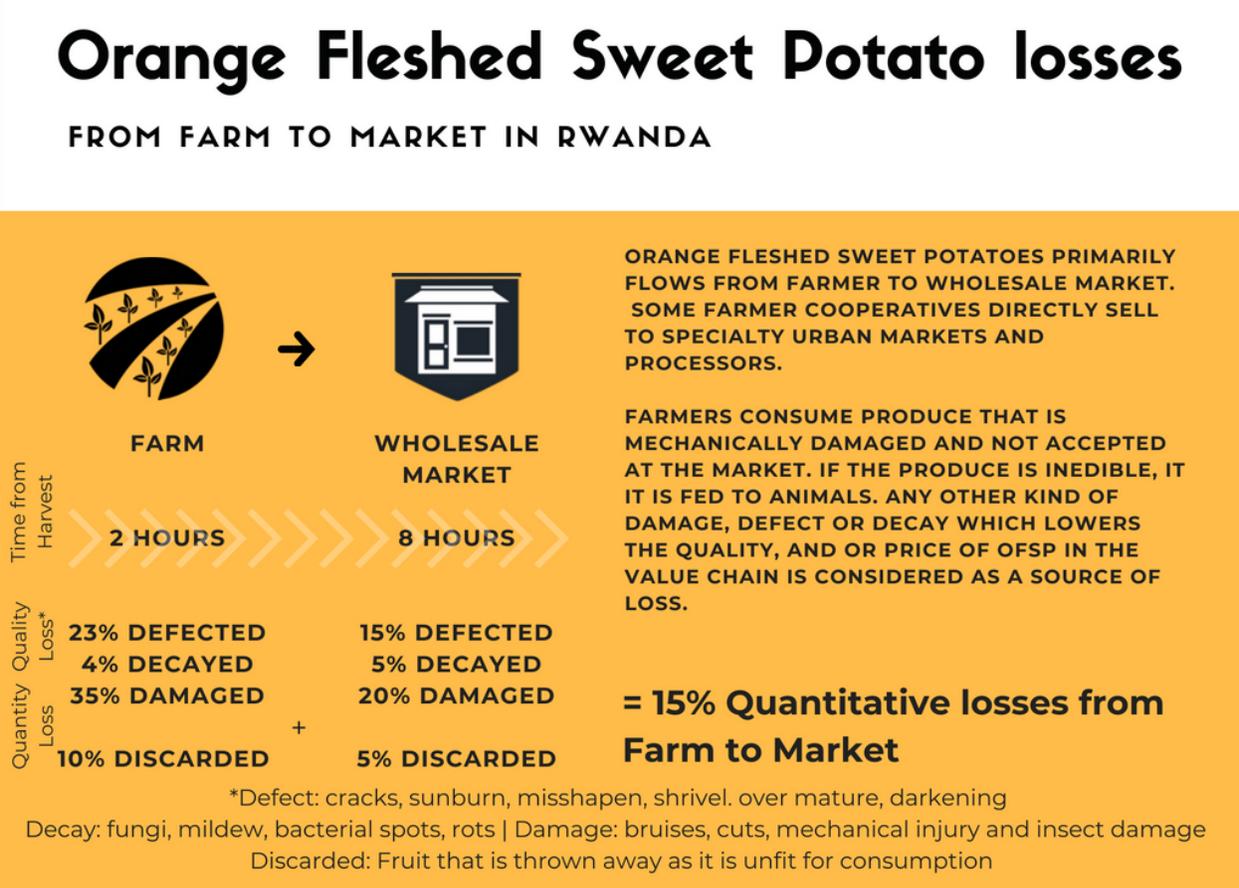


Figure 1: Orange Fleshed Sweet Potato Losses: From Farm to Market in Rwanda

OFSP is being grown in eighteen districts across the country - Muhanga, Kamonyi, Ruhango, Rulindo, Musanze, Burera, Gakenke, Ngororero, Rwamagana, Gatsibo, Kayonza, Karongi, Rutsiro, Rubavu, Gicumbi, Bugesera, Nyaruguru and Nyamagabe. Around 70% of sweet potatoes growers adopted OFSP and are being supported by RAB, CIP and other Non-Government Organizations (NGO) in the supply of vines and extension services.

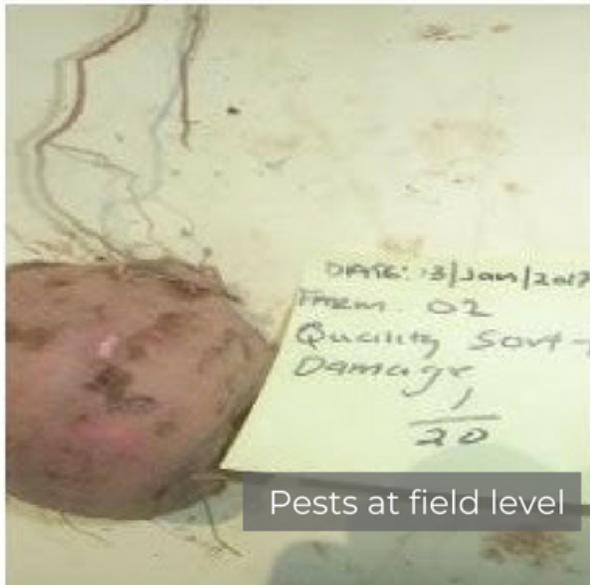
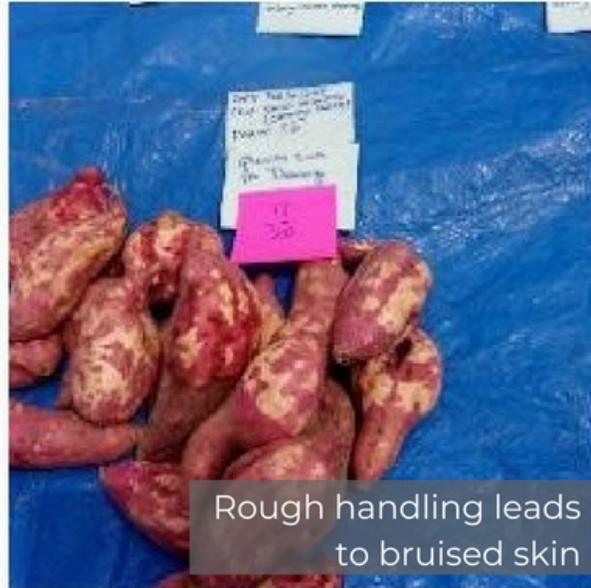


Figure 2: Causes of losses in Photos

Summary of postharvest losses and quality problems for OFSP:

Damage during Harvest	<ul style="list-style-type: none">• Traditional hoe harvest techniques can be very damaging. Once cut, if not cured, the tuber becomes more susceptible to degradation and insects• Rough handling• Farmer cash flow issues may result in early harvesting, leading to a poor-quality product (immature roots are too fibrous)• Farmers' use stagnant water to wash the tubers. This can induce fungal diseases.
Postharvest Handling	<ul style="list-style-type: none">• Rough handling leads to bruised and damaged skin of OFSP. OFSP is harvested by a hoe that cuts the produce. Workers move the produce from one point to the other on the field while sorting, loading, unloading and transport on their heads. Handling damage lowers the shelf life.• Weevil and other pest infestation due to cracking
Storage	<ul style="list-style-type: none">• Low use of adapted “curing”• Farmers use traditional practices such as storing in the ground or covered by grass, that require assessment• A CIP model storage solution (zero energy) was made of brick to protect against theft and was therefore expensive
Transportation	<ul style="list-style-type: none">• Accidents on bikes or while carrying loads on heads are common• Distance to travel is far and hilly terrain increases difficulties with transport

Recommendations for Reducing Postharvest Losses

<p>1</p>	<p>Training of trainers (capacity building) in improved practices. Farmers should be trained in maturity and quality indices, postharvest handling, curing, long-term storage and use of improved containers. In general, training on production, harvest and postharvest best practices is required. Target lead farmers and incorporate them into training and capacity building mandate</p>
<p>2</p>	<p>Demonstrations that are recommended for the Postharvest Training and Services Centers on cost effective practices for reducing postharvest losses include:</p> <ul style="list-style-type: none"> ● Use of improved containers for transport and marketing (smaller sizes, stackable baskets, plastic crates) ● Small-scale processing methods ● Zero energy cool chamber (ZECC) ● Hygiene and food safety
<p>3</p>	<p>Postharvest agri-business opportunities should be promoted. These include:</p> <ul style="list-style-type: none"> ● Entrepreneurial and business training for large scale farmers and vine multipliers (private sector) ● Investigate feasibility / needs of assembly points and collection centers, and their potential to be privately run ● Catalyzing entrepreneurs to provide postharvest storage and management services including packaging, handling, cooling technology and better transportation. ● Local manufacture of OFSP based products ● Smallholders need training on farming as a business



2. INTRODUCTION

Sweet potatoes in general (white and yellow fleshed varieties) are an important crop for Rwanda, particularly for food security. It is estimated that 70% of all Rwandans grow sweet potato, and it accounts for 13% of all crop production, with total production of 941,000 metric tons on approximately 70,000 hectares (Season B, the highest).¹ The average size of the smallholder sweet potato plot was just 0.02 hectares.

Despite high levels of production and consumption, since the beginning of the crop intensification program, sweet potatoes have not been under this program. The “priority staple crops were maize, rice, beans, Irish potato and banana.

Up to 82% of all sweet potatoes are consumed at the household level, with small-holders selling only between 13-22% of their produce (variation depending on season). Large scale farmers sold approximately 50% of their crop.² (SAS)

Orange Fleshed Sweet Potato (OFSP) has a similar production profile as the regular sweet potato, but has the added benefit of being high in Vitamin A, and therefore forms an important part of a household’s nutritional strategy. In a country where it is estimated that 44% of the population suffers from chronic malnutrition,³ OFSP is an important source of Vitamin A and helps to combat VAD (Vitamin A Deficiency syndrome). It is not a high value crop in economic terms, but the health benefits add to its value.

Though sweet potato is a traditional Rwandan crop, OFSP adds to the diversity of the Rwandan food plate. Official statistics on the current level of production of OFSP on Rwanda from the International Potato Center (CIP) were not available at the time of the survey.

Currently CIP is providing sweet potato vines to 80 – 100,000 households every season. They work primarily with vulnerable farmers for whom OFSP is intended for additional food security and nutrition.

Sweet potato can be made into a puree that becomes a flour substitute. CIP has supported various processing initiatives over the last eight years. These interventions had a dual focus: 1) support for cooperatives to engage in small- to medium-scale production of donuts and cakes, and 2) support for the quasi-industrial agribusiness Urwibutso Enterprises to engage in the production of biscuit and cakes.

¹ Seasonal Agricultural Survey, 2015

² Seasonal Agricultural Survey, 2015

³ CIP statistics www.cipotato.org

OFSP has not spread beyond the target districts supported by the CIP project; while the crop has many benefits, its spread is constrained by several factors, including lack of suitable varieties for local cuisine and local markets, primarily due to unfamiliarity with the crop.

Rwandans are fairly conservative in their consumption habits, and though it has gained some popularity in the areas covered by CIP, where there has been more than a decade of work, changing consumption habits is a long-term strategy and requires significant investment. In this sense OFSP can be considered an artificial industry in Rwanda, almost entirely created by the aid industry with continued levels of high support. While CIP's efforts have largely been successful, there are questions about the sustainability of OFSP if /when CIP's activities discontinue.

During our study we found it difficult to determine the market demand and the willingness of farmers for OFSP production.



3. VALUE CHAIN ANALYSIS

Methodology

In order to gain the correct insights and provide the basis for analysis of key constraints and challenges, the following tools were used:

- 1) **Literature Review** – A literature review of Rwandan agriculture and horticulture reports to date, including the *Strategic Plan for the Transformation of Agriculture in Rwanda Phase III* and the *Draft National Horticulture Policy and Strategic Plan* (2014). Statistical excerpts from the detailed *EU Baseline Report Survey on Horticulture* (2015) were also used where it pertains to the four crops in question, and farmers in general.
- 2) **Interviews** – Interviews were a major component and the analysis represents a series of interviews with key actors at each stage of the value chain, including but not limited to:
 - a. Producers / Farmers (small, medium, large; coops; companies)
 - b. Input supply agents and brokers
 - c. Financial institutions concerned with horticulture in general
 - d. Government ministries where applicable
 - e. Government institutions, including NAEB and Rwanda Agricultural Board (RAB)
 - f. Agriculture Extension workers (district level)
 - g. Traders in the selected crops (where applicable)
 - h. Wholesalers in the selected crops (where applicable)
 - i. Exporters (where applicable)
 - j. Processors
 - k. Transport agents
 - l. Retailers
 - m. Others as applicable
- 3) **Site visits – Observation through in field visits** to farms, markets and factories were critical to verifying and assessing activity.

Each Value Chain analysis was developed in conjunction with a local team who were trained on the methodology, as well as with representatives of the partner organizations in the Rwanda Postharvest Solutions for Horticulture project – National Agriculture Export Development Board, Rwanda Agricultural Board and the University of Rwanda.

Findings

Each stage of the OFSP value chain (Inputs; Production; Harvest and Post-Harvest; Marketing and Distribution; Processing, as well as Policy/Operating Environment) is highlighted with positive findings and key challenges emphasized.

Overall, OFSP has a very short and compressed value chain and due to the presence of a large processor, is the most “centrally managed” value chain compared to the other crops.

As much as possible, the value chain analysis is devoted to OFSP, but it should be noted that none of the farmers or co-operatives we interviewed were engaged exclusively in OFSP, but in sweet potato in general and OFSP only accounted for a percentage of their activity (30-50%, though that activity may be exaggerated due to the distortion effect noted in the Introduction section).

GOVERNMENT / OPERATING ENVIRONMENT

Rwanda supports crop production through land consolidated policy. Although, sweet potatoes were not a priority crop initially, it has gained momentum due to the nutritional components and the hidden hunger (micronutrients deficiency). Currently, the policy allowed specialized farmers to grow it in consolidated manner in order to promote the crop.

Extension services and district agronomists may work with sweet potato, and RAB has a dedicated unit to the crop (OFSP) and is heavily involved in seed certification and identifying and promoting appropriate varieties.

Financing remains a key challenge for all horticulture sectors, due to the inherent riskiness of the industry, as well as lack of knowledge or background amongst traditional banks. Lack of financing is even more exacerbated for processing, where risks multiply and investments are heavier.

INPUTS

Seeds

RAB and CIP have both devoted significant resources to optimizing seeds for OFSP, both for disease-resistant varieties as well as for varieties adapted to Rwandan's taste preferences. Seed certification has been a focus of recent efforts and the actors involved can claim solid success in controlling the varieties and the seeds, and RAB now offers certified seeds, as well as a certification process and program for vine multipliers (see below).

Vines

New crop planting is via vines or cuttings from existing sweet potato plants. For larger farmers and cooperatives, "multiplication" (as it is known) is a good business and more profitable than actual cultivation and sale of the tubers.

There is potential for more private sector actors in this area and RAB is actively promoting their engagement. Even though the vine multipliers may be private sector (either independent farmers, cooperatives or specialists in multiplication), the main purchasers / clients are organizations, who are purchasing the vines for distribution to their beneficiaries.

Although main focus of this study emphasized on the postharvest of tubers, farmers have shown a potential income in vines business. Therefore a net income potential from vines should be considered as an important part of the economic benefits of the OFSP, though the sustainability of this business remains a concern.

Other inputs

Disease was not cited as a major issue, primarily due to the successful control and certification of seeds. Fertilizer access or cost was not cited as an issue during our study.

PRODUCTION

Sweet potato in general and OFSP in particular are a relatively low-labor intensive crop; once planted, the vines, and tubers beneath the soil, generally grow without too much oversight. Crop rotation is not a major concern and land can be used for several consecutive seasons. All varieties of sweet potato, including OFSP, are produced and harvested in the same manner; the only difference is that OFSP can reach maturity in 3-4 months, while other varieties take 5-6 months.

Average yield in Rwanda is 7 tons / hectare⁴ but with improved seeds and production processes, yields can rise to 15 tons / hectare per season.

The main challenge in production include farming on hillside without irrigation system especially in long droughts. Interviewed farmers shown that climate change was the major challenge for OFSP and traditional sweet potato production. Some of the larger farmers interviewed use basic irrigation systems (use of cans). Additional climate-related challenges include torrential rains as it happened in 2016 where 80% of production was lost both on hillside and marshlands

RAB as the main extension institution trained the agronomists who are mandated to ensure the same to their beneficiaries.

HARVEST AND POST-HARVEST

A tuber, the sweet potato is left in the ground until harvested, and there is a certain amount of leeway in terms of when harvest can occur, offering a sort of “pre-harvest” storage option, albeit one that keeps land uncultivated with the next crop.

OFSP can also be “cured” for several days using simple technologies – cleaning and cutting off ends – and once properly cured, can be stored underground for up to 6 months in a hole, covered with grass and sand, and with a bamboo stick for aeration. Farmers using this method claim that it can store sweet potatoes for 6 months. It is important in this method that no cracking occur, or

⁴ Seasonal Agricultural Survey, 2015

weevils will infest the tuber.

The main challenges for OFSP at the harvest and post-harvest level include:

Damage during harvesting

- Traditional hoe harvest techniques can be very damaging. Once cut, if not cured, the tuber becomes more susceptible to degradation and insects
- Rough handling
- Farmer cash flow issues may result in early harvesting, leading to a poor-quality product (immature roots are too fibrous)

Low use of appropriate post-harvest handling methods

- Low use of adapted “curing”
- Weevil infestation due to cracking

No low-cost storage solutions available

- The viability of the traditional storage methods explained above need to be confirmed
- There also needs to be a determination if storage methods are required, specifically for OFSP and anticipated volumes
- A CIP model storage solution charcoal cooler was made of brick to protect against theft and was therefore expensive

Road conditions and transport issues increase postharvest losses

- Accidents on bikes or while carrying loads on heads are common
- Distance to travel is far and hilly terrain increases difficulties with transport

It's not certain that the quantity of OFSP being produced and the market sufficiently large to warrant large investments in storage solutions.

MARKETING AND DISTRIBUTION

Most OFSP is grown for home consumption and is produced by small farmers. For off-farm sales, the OFSP marketing and distribution system is compressed and the closest thing approaching a centrally managed value chain, with one large buyer purchasing from dedicated suppliers.

There are no wholesalers specializing in OFSP, nor do there appear to be any sweet potato wholesalers in general, pointing to the auto-consumption and local trade aspect of this crop. Some specialty wholesalers serving the Kigali market carry OFSP. Price fluctuations didn't seem to be a key issue, probably because the crop is not traded in any significant volume. Generally, prices would be RFW 150/kg to the processor, and RFW 200-250/kg on local markets. Some

farmers claimed a premium for OFSP, while others said prices were identical. OFSP is often sold mixed in with other types of sweet potato, indicating no price difference and sometimes no consumer differentiation either.

The processor buys at pre-contracted prices though some farmers are not satisfied by the given price which is in the range of 120 – 250 Frw/Kg. Farmers estimate the cost of production at RFW 300/kg, based on their expenses in terms of time, labor and agricultural inputs. According to farmers the only reason of keeping producing OFSP is due to the vines multiplication business.

In Rulindo area where the processing plant is located, for transportation of fresh produce is done by farmers themselves. For a fixed contract of 3 months, every supplier should at least bring a minimum of 35 Kgs/week, although farmers claimed to bring every quantity available.

CIP has put much effort and emphasis on growing the niche Kigali market for OFSP, with a strategy to make OFSP attractive to appeal to the urban market. They have had some success connecting cooperatives to Kigali buyers (hotels, websites, and bakeries) but overall the market remains small.

It was observed that in some CIP district, none or few OFSP were available in local market though there were significant quantity of regular sweet potato for sale. Since all varieties have similar production methods, OFSP has a comparative advantage of short maturity period. However, OFSP has not reached the same demand as other sweet potato varieties.

PROCESSING

Many potential products can be made from the OFSP, and the following graphic shows potential processing options:

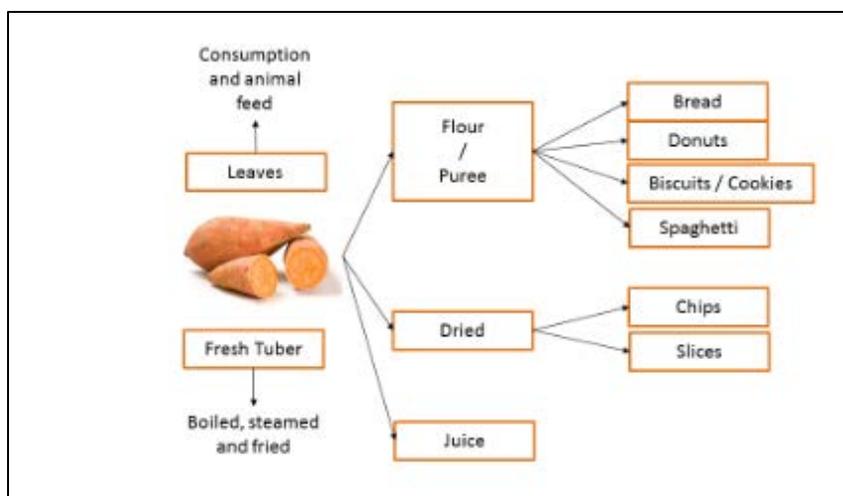


Figure 3: OFSP Product Map

The flour or puree from the sweet potato can be used as a lower-cost flour alternative. Wheat provides the gluten, while the sweet potato batter (up to 50% as substitute) provides a lower cost (especially in the Rwanda context, where wheat is imported) and healthier ingredient.

In the second phase of their projects in the country, processing was one of CIP's key pushes. The processor was extensively supported to produce biscuits and juice. They have one well-packaged biscuit product that appears to be quite successful, but we were unable to get exact quantities or determine demand.

During the survey, there were no raw material available to the processing plant due to shortage of OFSP produce.

Other supported cooperatives which received the provision of industrial mixers, deep fryers and ovens for OFSP processing have faced the same challenges but also some internal management issues. However, some of them are still making doughnuts and cakes while others have stopped completely due to poor management. ;

According to CIP, future activities will be concentrated on nutritional and food security benefits of OFSP rather than processing.

OFSP ACTORS AND MARKET SYSTEMS

A. THE CIP UNIVERSE

In Rwanda, CIP are champions of OFSP and are the most important player in the OFSP space. Via their OFSP-focused projects (SASHA I and II; currently SUSTAIN 2008-2018) they provide

support to all major areas of activity, as outlined below:

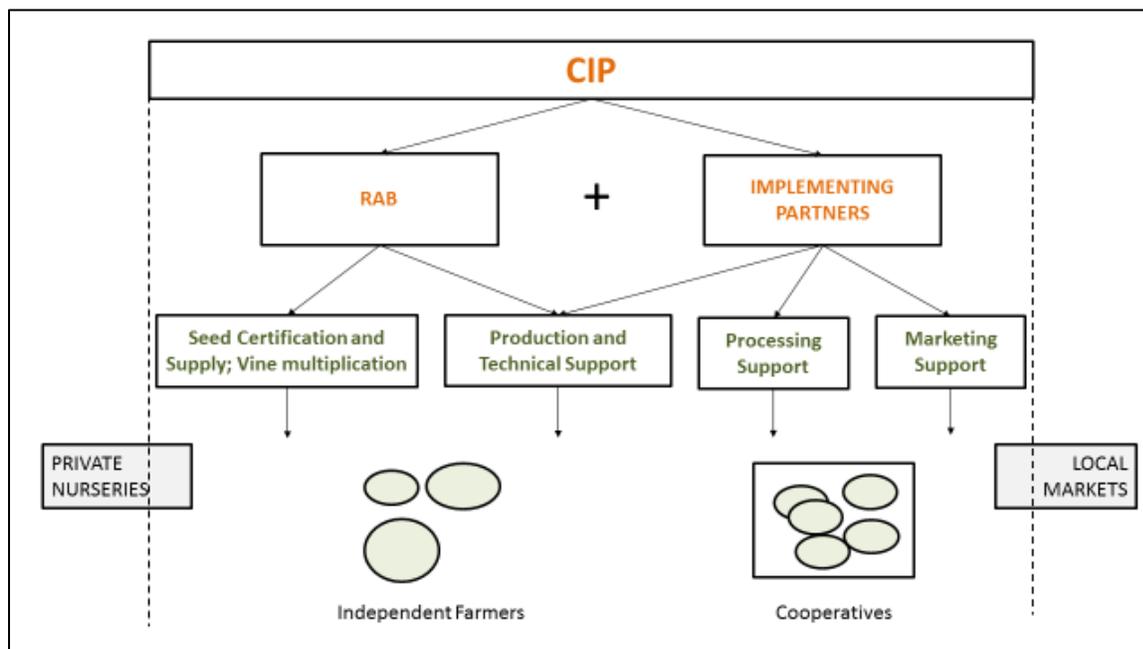


Figure 4: The CIP OFSP Universe

There is very limited activity beyond what CIP supports, and there appears to have been no independent uptake into new districts by interested farmers, though some farmers initially supported by CIP have grown big enough to self-fund their own expansion.

B. PRODUCERS

PRODUCER SEGMENTATION

The following types of farmers are involved in OFSP production:

Small farmers for household consumption

- Small farmers account for the vast majority of growers of OFSP. CIP has targeted women, pregnant women and vulnerable populations
- Focused on nutritional and food security benefits
- Very small space dedicated to OFSP, as small as a few square meters
- Low quality production process and low use of intensification methods
- Targeted for expansion; CIP claims that in one month alone, 88,000 new vulnerable households were provided with OFSP vines

Cooperatives / Farmers' Associations

- Engaged in sweet potato production; OFSP does not represent the majority of their efforts

- Have received significant support – training and equipment – in production, processing and marketing
- May supply large processor (Urwibutso)
- Include vine multiplication business alongside tuber production

Large Farmers

- > 1 ha of land dedicated to sweet potato (though not necessarily to OFSP)
- Generally started as small-scale farmers that have, by their own dedication and efforts, grown larger and expanded production by acquiring or leasing land
- Strongly dedicated to sweet potato in general and OFSP, and practice improved production and harvesting
- May irrigate
- May have storage solutions (CIP-supported)
- Vine multiplication is most important business, ahead of tuber production

Private vine multipliers and nursery operators

- Small group of private sector entrepreneurs who have backward integrated into tuber and vine production
- Similar production techniques and level as large farmers profiled above
- Private sector but most of their clientele are aid groups and NGOs

The co-operatives, large farmers and entrepreneurs are by far the most interesting group for the PHC to work with. All groups have the potential to produce the volumes that make storage an issue, and they have the capacity to understand the importance of and take advantage of improved post-harvest handling.

During survey, it was found that there were some very successful farmers who have built large farms dedicated to OFSP. Although they are few, it is interesting to share their success in order to encourage and support other farmers to achieve similar goals.

C. PROCESSORS

There are three main groups of processors involved in the OFSP sector, as shown by the following summary graphic:

	“Kitchen”	“Agri-preneur”	“Industrial”
Description:	Small scale, may have a few pieces of donated equipment, run by farmers’ groups	Non-farmer looking to invest in processing	Long time agribusiness enterprise with large scale production capacity
Access to Capital	LOW	LOW →	MEDIUM
Access to Supply	MEDIUM	LOW →	MEDIUM
Distribution / Marketing	LOW	LOW-MEDIUM →	HIGH
Human Capital / Managerial Capacity	LOW	MEDIUM	MEDIUM

These areas represent the major barriers for small processors to achieve scale

Figure 5: Processors Involved in OFSP

Small-scale Processors

Cooperatives were initially supported by CIP and received significant investments in modern baking equipment. Some appear to still be doing small-scale processing, though others have abandoned it.

The main challenge for this group include their lack of managerial capacity, often cited as the number one reason for failure – farmers are producers and running a financially driven, value-added activity is several steps up in terms of their experience. They also lack the marketing and distribution channels so crucial to success, and without the proper packaging or the ability to assure a constant volume of high quality product, they were unable to develop and durable market links with retailers.

“Agri-Preneurs”

This is a group of non-farmers attracted to OFSP processing and have got support from CIP through its sensitization program. This group also include some young entrepreneurs with little experience agribusiness although highly motivated. These motivated entrepreneurs were not producing any OFSP product during the survey. These potential processors are hampered by lack of access to financing, which in turn impacts their activity. For agri-preneurs, the OFSP doughnuts has the biggest market share among their processed products.

“Industrial” producer

The only success in processing OFSP appears to be with Urwibutso Enterprises. They are a

large, diversified agribusiness enterprise with a long list of products (primarily oils, juices and bakery products including wheat bread). For them, OFSP is a relatively small line item but one from which they have benefited immensely in terms of equipment and investment from CIP. In addition to financial support, they already established marketing and distribution channels, as well as experience working with local farmers (as they do for fruit farmers for their juices and chili farmers for their oils).

D. MARKET ACTORS AND SYSTEMS

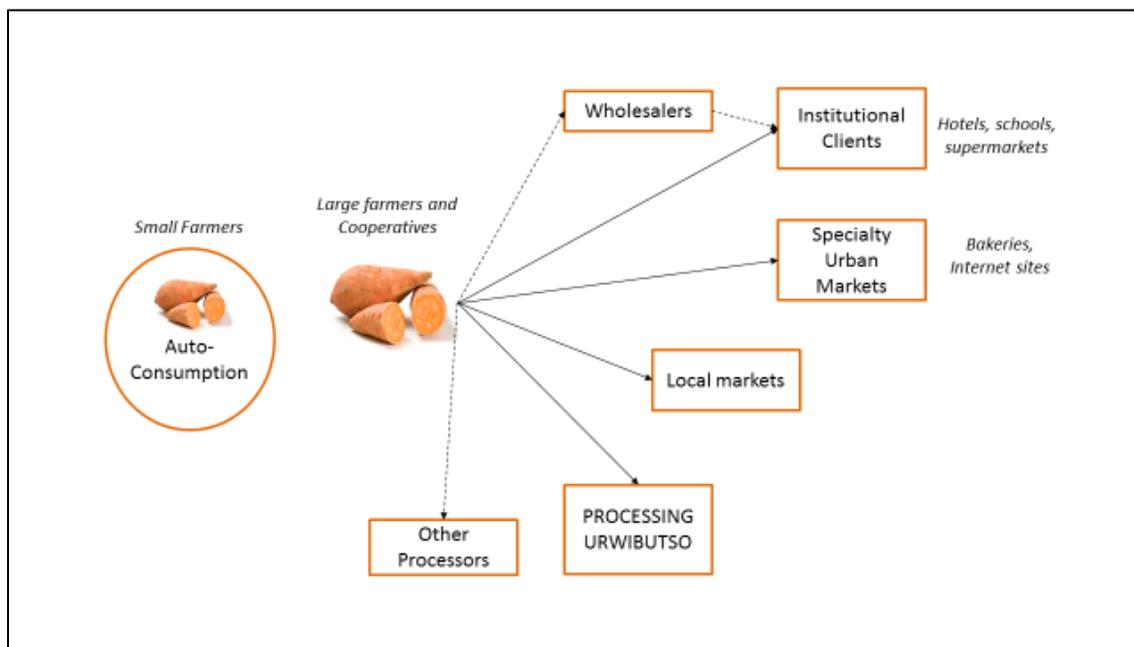


Figure 6: Marketing And Distribution Map

As shown above, the marketing chain is short and compressed with relatively few players and a short overview has been provided above under the Value Chain analysis.

E. END MARKETS

There are several end markets for OFSP:

Local Markets – Produced and sold locally; often OFSP is mixed in with other types of sweet potato

Daily spot wholesale markets in Kigali – sweet potatoes in general may be traded at these central markets but OFSP is not

Niche Urban Markets – CIP has had good success in establishing market links between cooperatives and large farmers with bakeries, hotels and websites that offer fresh food delivery in Kigali. These markets are very small but their future growth remains strong and this is an interesting market for producers of tubers to continue to focus on.

Institutional Markets – such as schools and hospitals. With the added benefit of its nutritional density, these markets would prefer the OFSP over other sweet potatoes as long as the price remains the same. Currently large sweet potato farmers do supply these markets, but the majority of their produce is sweet potato of other varieties, not OFSP, though all indicated that the institutions would prefer OFSP if it were available. With the right contracts and systems in place, these institutions could be drivers of consistent supply.

Regional exports - There does not appear to be any regional exports of OFSP (either tuber or finished product) and no demand or potential for such.

RECOMMENDATIONS AND INTERVENTIONS

A. VALUE CHAIN INTERVENTIONS

SUMMARY AND APPROACH

As with the other crops, the following interventions are divided into two main categories: those that exist for an enabling environment or government level, and those that may be within the scope of the Postharvest Centers, for example those interventions that are training- or capacity-building based; those that are collaborative, cluster building, and focused on facilitation and bringing producers together, and finally those that require only minimal investment in equipment or materials.

We anticipate that not all will be under the scope of the project, and that one key initial activity will be prioritizing the interventions and developing a schedule for their implementation.

INPUTS & PRODUCTION - RECOMMENDATIONS

Government / Policy Level Interventions

- CIP to continue lobbying government for importance (nutritional) of OFSP

Potential Project-Level Interventions

- Incorporate private seed multipliers in activities geared at entrepreneurial and business capacity building

- Work with RAB to demonstrate best practices vine planting and cultivation
- Target lead farmers and incorporate them into PHC training and capacity building mandate

HARVEST AND POST HARVEST RECOMMENDATIONS

Government and Policy-Level Interventions

- For OFSP quality protection, the MINAGRI should develop directives for use of appropriate packaging materials like crates.
- Continued government support for *Ubudehe* program targeting improvement of small and secondary roads
- Continue support for development of local packaging industry

Potential Project-Level Interventions

- Identification of traditional practices in order to translate them into new or improved ones.; work in collaboration with CIP and implementing partners
- Support the farmer groups for improved or modern harvesting and post-harvest handling and marketing techniques.
- Develop and support on-farm training in curing of OFSP produce.

MARKETING & DISTRIBUTION RECOMMENDATIONS

Potential Project-Level Interventions

- Support all production and post-harvest efforts to increase yield and therefore volume
- Work with cooperatives and / or large farmers on strategies to increase institutional clients
- Entrepreneurial and business training for large scale farmers and vine multipliers (private sector)
- Investigate feasibility / needs of assembly points and collection centers, and their potential to be privately run

PROCESSING RECOMMENDATIONS

Government and Policy-Level Interventions

- Continue support for development of local packaging industry

Potential Project-Level Interventions

- Incorporate current and potential investors in this space in the Postharvest Training Centers' activities
- Work with processors – all levels – to overcome both technical hurdles and managerial / leadership challenges (see below)

- Work with medium-scale entrepreneurs on their business plans for OFSP processing; conduct detailed study on market potential for OFSP products
- Support measures to increase supply to support the development of steady supply for potential processors
- Raise awareness with banks and financing institutions about agribusiness investments, risks and the industry in general

B. ENTREPRENEUR / PROCESSOR BUSINESS CAPACITY BUILDING INTERVENTIONS

The focus of the Training Centers will be on technical postharvest training, addressing the issues outlined above, but given that horticulture is a risky, fast moving commercial sector, producers will also benefit from business skills and entrepreneurial training. Once core target groups are identified, training needs and programs can be developed that target horticulture entrepreneurs in general, and OFSP entrepreneurs specifically.

The suite of suggested activities for processing entrepreneurs is similar to business training suggested for farmers, but focused on manufacturing and value-added products. This type of training would of course be extended to processors of other crops.

Training programs including the following subject matter could be developed by the Postharvest Training Centers:

- Understanding price fluctuations and demand and supply
- Understanding value chains and pricing
- Working with suppliers: production and post-harvest
- Conducting market research
- Operational and managerial planning
- Manufacturing challenges
- Distribution and sales channels
- Product marketing
- Legal context: Dealing with local legislation and government; labor laws, taxation
- Benefits of collaboration and clustering with other processors (other industries), for purchasing and increasing industry power
- Finances: Calculating profit and loss, and tracking expenses; capital investments
- Accessing financing support and resources
- Strategic thinking and long term planning



4. COMMODITY SYSTEMS ASSESSMENT

Methodology

Commodity Systems Assessment Methodology is a step-by-step methodology for describing and evaluating the planning, production, postharvest handling and marketing of agricultural commodities. The modified CSAM (Lagra, Kitinoja and Alpizar, 2016) includes interviews of stakeholders, observations of handling practices, and direct measurements of quality and quantity losses on farm, and at the wholesale and retail market levels (for domestic markets). The field based measurements at the farm and wholesale market, have increased the knowledge base in Rwanda and helped to identify priority postharvest problems that currently limit market access for small farmers and rural marketers. Results from the rapid assessment provides input we can use to promote technology awareness, adoption and utilization, as well as answer key research questions to inform the project and the postharvest subsector in Rwanda.

The CSAM report includes:

- the average and range of postharvest losses
- losses segregated by category (physical injury, pathological disease, insect damage, water loss, other) at each stage in the postharvest value chain
- the estimated loss of market value for the crop
- recommendations for reducing postharvest losses

CSAM data collection methods and protocols

CSAM is a systematic process of using surveys, interviews and observations to collect data on the key aspects of the value chain, including production, postharvest handling and marketing. It considers the entire commodity system, from planning and production to processing and marketing, but we will focus more on the postharvest and marketing aspects trying to determine the relative costs of any potential or observed changes in handling, containers, value addition or marketing practices.

Data on the OFSP value chain in Rwanda was collected via interview following a set of written questions (Annex 1), observation and field measurements. Questions related to production are asked mainly to farmers, marketers are asked about marketing and transport, processors are asked about postharvest handling and packaging and researchers, project staff and or extension workers about the entire system. A desk review of published articles, reports and unpublished documents was also used to source information.

Additionally, there are worksheets used for on-farm (Annex 3) and Wholesale (Annex 2) data collection on postharvest losses, quality characteristics, market value chain changes, general shelf life of raw materials and processed products.

A complete CSAM, collects data at 26 points, along the value chain, as shown in the image below.

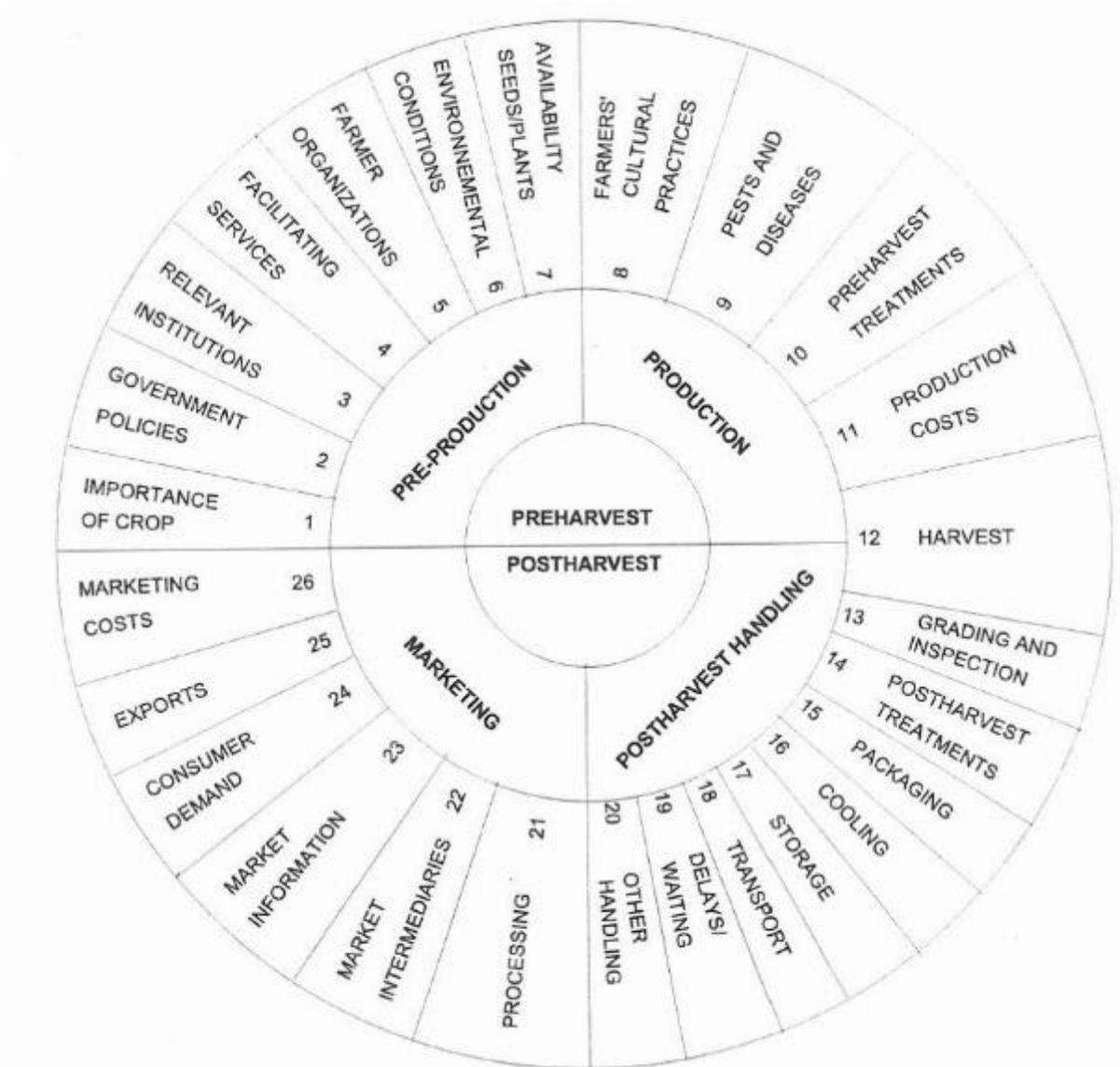


Figure 7: Principal components of a CSAM (LaGra 1990)

Sampling protocols

The goal of the assessment was to sample postharvest losses for a random selection of 10 farmers. Due to seasonality challenges the study team was able to reach 9 farmers. CSAM interviews were conducted with 12 persons, via a stratified sample of known experts, extension workers, farmers, traders, processors and marketers.

Tools used to measure losses

CSAM team members go to the field carrying with them a set of tools that will help them measure different parameters that will help assess quality and losses. (Annex 6)

- Scales to assess the weight loss caused by postharvest practices
- Cameras to report the quality of the crop and handling practices at any segment of the value chain
- Digital thermometer (temperature probe) to measure the temperature and the relative humidity of the environment at the time of the visit

Site selection for the OFSP CSAM study

The farmers in open field and processors of OFSP were surveyed in 2 districts - Rulindo and Gakenke, and processors were visited in Muhanga and Gasabo districts. The study team also contacted OFSP farmers from Rwamagana, Muhanga and Kamonyi but they were not ready yet to harvest due to climate variability. The farmers reported that the agricultural season was affected by the dry season, that was longer than usual in 2017. These area of study were chosen after consulting RAB and CIP staff supporting OFSP farmer growers.

Besides that, most of farmers are working under cooperatives, some of whom have their own farms. The individual farms size ranged from 0.2 to 2 hectares as their own property or rented while the size for farm cooperatives used for OFSP cultivation ranged from 0.5 to 2 hectares. In both situation, farms were located in different places mostly in marshland and uphill far from the main road. Two processors located at Gakenke and Muhanga districts were visited and both of them are being supported by CIP. They have received some Processing Machines, technical support and management skills assistance as confirmed by Dr Kilimi Sindi, the country representative of CIP.

Urwibutso enterprise is also involved in OFSP processing located in Rulindo district, and it was also visited by the team.

Findings

The following is a summary of the major findings for the crop. On the whole, losses are low compared to other horticultural crops and defected and decayed OFSP is often auto-consumed at home or if the quality is very bad, then it is fed to animals. Interviews and observations identified several key issues, including defects caused by rough handling as well as sunburn. A high percentage of OFSP had mechanical damage including bruises and cuts mostly caused during harvesting with a hoe and rough handling. While, to a lesser extent, OFSP sampled showed signs of decay including symptoms such as fungi, mildew, bacterial spots and rot. There was also some indication of insect damage.

1. Farmers use stagnant water to wash the tubers. This can induce fungal diseases.



Figure 8: OFSP washing on field with stagnant water

2. Rough washing and handling leads to bruised and damaged skin of OFSP. OFSP is harvested by a hoe that cuts the produce. Workers move the produce from one point to the other on the field while sorting, loading, unloading and transport on their heads. Handling damage lowers the shelf life.



Figure 9: Bruised OFSP at farm level

3. Pests such as flea beetles, wire worms, aphids, early blight and black leg disease lead to losses.

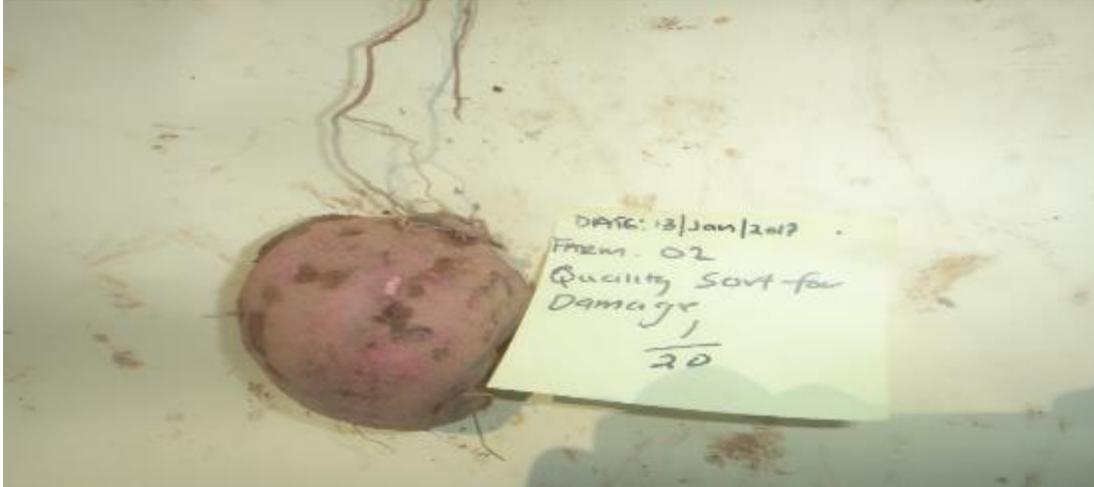


Figure 10: tuber affected by pests at field level

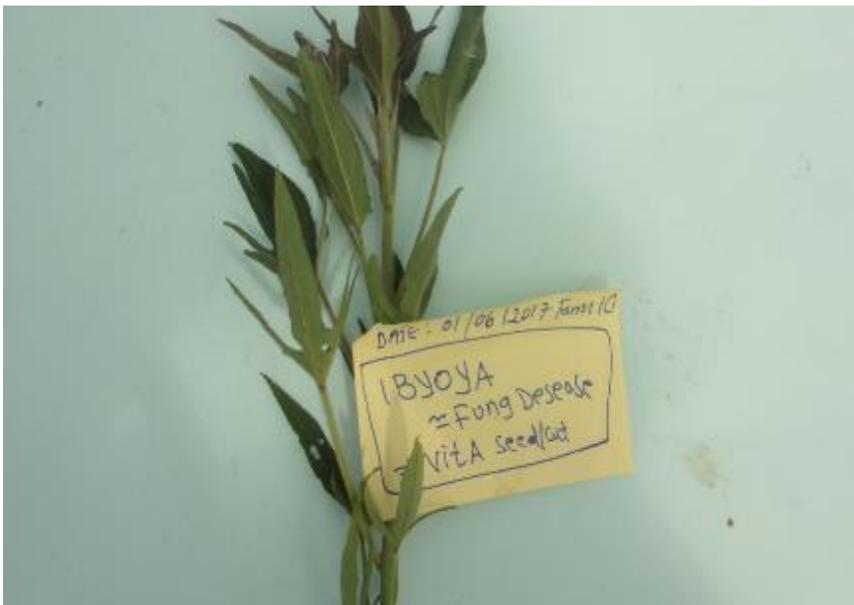


Figure 11: OFSP vines attacked by black leg disease causing pit hole scars

4. Farmers are not trained in proper storage of OFSP especially curing. Most farmers store in the ground (long term) or covered in grass (short-term).



Figure 12: OFSP stored under dried grass

The main observations by CSAM component are highlighted below.

Table 1: CSAM Findings Summary - Causes and Sources of Losses for OFSP in Rwanda

CSAM Components	Interviews and Observations	Recommendations
PLANNING/ PRE-PRODUCTION	<ul style="list-style-type: none"> • The local climate and soil factors limit the quality and also the farmers need to grow appropriate varieties that are suitable to their location and in demand • At the time of the survey, the rainy season was short which negatively affected the yield in some places like Kamonyi, Bugesera and Rwamagana 	<ul style="list-style-type: none"> • Varieties that are suited to the taste of Rwandans should be promoted
PRODUCTION	<ul style="list-style-type: none"> • Pests such as flea beetles, wire worms, aphids, black leg disease and early blight was noted 	<ul style="list-style-type: none"> • Farmer training on integrated pest management
POSTHARVEST	<ul style="list-style-type: none"> • Damaged OFSP is auto-consumed and severed damaged tubers are used as animal feed. • Farmers wash OFSP with stagnant field water. • Farmers harvest only when the tubers are ready and there is a buyer. Some farmers store the OFSP in the ground or under grass to offer coverage and shade. • The OFSP is roughly handled and handled too many times. 	<ul style="list-style-type: none"> • Farmers to be trained on proper postharvest handling and storage including curing, storage methods such as ZECC, food safety etc. • Farmers should not wash roots and just store in bins or crates. Roots should be washed before packing for marketing. • Roots should be stored in evaporatively cooled rooms, supplemented by mechanical refrigeration.

	<ul style="list-style-type: none"> ● Packaging is done in big gunny sacks that also cause compression damage 	
MARKETING	<ul style="list-style-type: none"> ● OFSP is being processed into biscuits and cakes by one major enterprise and a few cooperatives 	<ul style="list-style-type: none"> ● Market research to be done on acceptable products and their demand by consumers ● Research on more processing options for OFSP

The OFSP varieties grown in Rwanda includes: Kabode, Terimbere, gihingumukungu, VitA, and Kakamega.



Figure 13: OFSP Varieties

Table 2: OFSP Seasons

Cultivation Time	Harvesting Time	Harvesting Methods	Who Harvests
November-December	March-April	Manually using a hoe	Farmers and workers
March-April	August-September	Manually using a hoe	Farmers /workers

OFSP Processing

Stored OFSPs are processed into different products such as flour, puree, bread, biscuits, donuts and cakes



Figure 14: OFSP Processing

Market research to understand consumer tastes is important along with product development for more widespread consumption of OFSP products. Hindering this is appropriate packaging for all OFSP products. Urwibutso's products are of high quality and have good packaging.

Postharvest Quality and Food Safety

The CSAM team interviewed different actors of OFSP value chain. Those who are mostly handling the produce, do not know about food safety, hygiene and sanitation. They have experience in what they are doing and they are eager to learn to increase their skills. However, they need some training on how to handle the produce. For example while washing in stagnant water, the farmers end up removing the pulp skin without knowing that the OFSP is being damaged, and can easily be attacked by molds, yeast and or fungi.

The Journey from Farm to Market

The size of the OFSP farms ranged from 0.5 to 2 hectares with the average of 0.7 hectares. The distance from the farm to market ranged from 0.5 to 6 km with the average of 2.5 km. However, processors are receiving produce from different places; Urwibutso Enterprise reported that they receive produce from farmers from as far as 42km and a wholesaler located in Gasabo district, reported to receive the produce from up to 400 km.

The team collected data on the farm at the same time as harvest - from 8 am in the morning to 2pm afternoon with maximum interval of 2 hours from harvesting to data collection. This was depending on number of farmers per day and the size of the farm to be harvested; like Urwibutso

Enterprise was harvesting from early in the morning until evening because they need a large quantity of produce from their own farm. Other farmers harvest a small quantity depending on their customer's order.

Inside the farm, the produce is harvested, sorted and if water is available, it is washed. Thereafter, the OFSP is transported to the main road or to the center where the wholesaler is coming to pick them. Sometimes they record the weight on sisal gunny sacks that are loaded on the truck from the district and make an arrangement with the customer in Kigali. The Kigali customer meets the truck on arrival for offloading and makes the agreed payment using money transfer services like mobile money or tigo cash. The sacks normally weigh between 50-100kg for easy loading. However, it is not common for OFSP to be found in the public market in Rwanda.

Table 3: Quality characteristics of OFSP in Rwanda

OFSP	Relative perishability*	N	Air Temp °C	Pulp Temp °C	Package protection**
Farm	3	7	32.0 ⁰ C	28.15 ⁰ C	1
Whole sale	1	2	32.2 ⁰ C	23 ⁰ C	5

*1=low, 3=moderate, 5=extreme (damage, decay of defect)

**1=weak, 3=moderate, 5= Excellent protection

Postharvest losses for OFSP

The data collected on defects (cracks, sunburn, misshapen, shrivel. over mature, darkening), decay symptoms (fungi, mildew, bacterial spots, rots) damage (bruises, cuts, mechanical injury and insect damage) for OFSP are summarized in the table below:

Table 4: Postharvest % losses for OFSP in Rwanda

OFSP	Relative perishability*	N	Avg Time from harvest	% Defects	%Decay	% Mechanical damage	% Sorted out /discarded before sale
Farm	3	7	2	22.5%	3.5%	35%	10% (from 5-15%)
Whole sale market	1	2	8	15%	5%	20%	5% one case

1=low, 3=moderate, 5=extreme (damage, decay of defect)

During this study, the CSAM team observed postharvest losses of OFSP value chain estimated to 20% although in most of the cases farmers are not aware of their losses. For example, when the

produce is used as animal feed instead of human consumption, the farmers do not consider this as a loss. Farmers also auto consume produce that is mechanically damaged and not accepted at the market. Any other kind of damage, defect or decay which lower the quality, and or market of OFSP in the value chain is considered as a source of loss.

Recommendations

Identification of research needs:

- Effect of OFSP water loss after harvest and appropriate shade
- Optimization of storage conditions of OFSP puree
- Effect of premature harvested OFSP on processing
- Optimization of storage conditions of OFSP using curing methods
- To conduct more research and development on OFSP varieties to increase vines suitable for the whole country
- To study bacterial and fungal diseases which may reduce the OFSP production
- To conduct more research and development of OFSP food products for more recipes
- To conducts research on OFSP leaves products

Identification of training needs for reducing losses

- Training on storage methods: curing and Zero energy cooling system (ZEC)
- OFSP disease management
- Training on Postharvest handling and management including appropriate harvesting time, produce handling during harvesting, hygiene and food safety management
- Training on washing of the produce with safe water to avoid mold and bacterial contamination
- Training on Management skills; for example of record keeping and cost benefits analysis
- Training on Good agriculture practices (GAP)

Advocacy issues affecting the postharvest losses of the crop

- In some places, infrastructure like roads are not appropriate, which could negatively affect the transport of the produce
- To encourage wood baskets or crates through a proper synchronized system that involves all the stakeholders to reduce losses at transportation
- Need to encourage farmers to work under cooperatives
- Access loan facilities and access sustainable market and government services

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Annexes

Annex 1: CSAM Questionnaire

Crop value chain assessment for the Reducing Postharvest Losses in Rwanda project.

CROP # 1 _____

Components 1 - 7: Pre-Production

(Data sources include extension workers, researchers, project partners)

1- Importance of the crop. What is the relative importance of the crop? Base your estimate of importance on information on number of producers, amount produced, area of production, and/or market value.

2- Governmental policies. Are there any laws, regulations, incentives or disincentives related to producing or marketing the crop? (e.g., existing price supports or controls, banned pesticides or residue limits)

3- Relevant institutions. Are there any organizations involved in projects related to production or marketing the crop? What are the goals of the projects? How many people are participating?

4- Facilitating services. What services are available to producers and marketers (for example: credit, inputs, technical advice, subsidies)?

5- Producer/shipper organizations. Are there any producer or marketer organizations involved with the crop? What benefits or services do they provide to participants? At what cost?

6- Environmental conditions. Does the local climate, soils or other factors limit the quality of production? Are the cultivars produced appropriate for the location?

7- Availability of planting materials. Are seeds or planting materials of adequate quality? Can growers obtain adequate supplies when needed?

Components 8 - 11: Production (Data sources include farmers, extension workers, project staff)

8- Farmers' general cultural practices. Do any farming practices in use have an effect on produce quality (irrigation, weed control, fertilization practices, field sanitation)?

9- Pests and diseases. Are there any insects, fungi, bacteria, weeds or other pests present that affect the quality of produce?

10- Pre-harvest treatments. What kinds of pre-harvest treatments might affect postharvest quality (such as use of pesticides, pruning practices, trellising, thinning)?

11- Production costs. What are the costs of any proposed alternative methods?

Components 12 - 21: Postharvest

(Data sources include farmers, extension workers, marketers, processors, project partners)

12- Harvest. When and how is produce harvested? by whom? at what time of day? Why? What sort of containers are used? (if possible, take photos). Is the produce harvested at the proper

maturity for the intended market? What is the temperature at harvest time? What amounts and types of losses are observed/reported?

13- Grading, sorting and inspection. How is produce sorted? by whom? Does value (price) change as quality/size grades change? Do local, regional or national standards (voluntary or mandatory) exist for inspection? What amounts and types of losses are observed/reported? What happens to culled produce?

14- Postharvest treatments. What kinds of postharvest treatments are used? (Describe any curing practices, cleaning, trimming, hot water dips, etc.) Are treatments appropriate for the product? (if possible, take photos).

15- Packaging. How is produce packed for transport and storage? What kind of packages are used? Are packages appropriate for the product? Can they be reused or recycled? (if possible, take photos).

16- Cooling (if any). When and how is produce cooled? To what temperature? Using which method(s)? If temperature measured during cooling? Are methods appropriate for the product? If produce is not cooled. What is the ambient temperature range during the postharvest period?

17- Storage (if any). Where and for how long is produce stored? In what type of storage facility? Under what conditions (packaging, temperature, RH, physical setting, hygiene, inspections, etc.)? Is the temperature measured while the produce is in storage? (if possible, take photos).

18- Transport. How and for what distance is produce transported? In what type of vehicle? How many times is produce transported? How is produce loaded and unloaded? (if possible, take photos).

19- Delays/ waiting. Are there any delays during handling? How long and under what conditions (temperature, RH, physical setting) does produce wait between steps?

20- Other handling. What other types of handling does the produce undergo? Is there sufficient labor available? Is the labor force well trained for proper handling from harvest through transport? Would alternative handling methods reduce losses? Would these methods require new workers or displace current workers?

21- Agro-processing (if any). How is produce processed (methods, processing steps) and to what kinds of products? How much value is added? Are sufficient facilities, equipment, fuel, packaging materials and labor available for processing? Is there consumer demand for processed products?

Components 22 - 26: Marketing

(Data sources include farmers, traders, wholesale marketers, retail marketers, consumers, extension workers, project partners)

22- Market intermediaries. Who are the handlers of the crop between producers and consumers? How long do they have control of produce and how do they handle it? What amounts and types of losses are observed/reported? Who is responsible for losses /who suffers financially? Is produce handled on consignment; marketed via direct sales; move through wholesalers?

23- Market information. Do handlers and marketers have access to current prices and volumes in

order to plan their marketing strategies? Who does the recordkeeping? Is information accurate, reliable, timely, and useful to decision makers?

24- Consumer demand. Do consumers have specific preferences for produce sizes, flavors, colors, maturities, quality grades, packages types, package sizes or other characteristics? Are there any signs of unmet demand and/or over-supply? How do consumers react to the use of postharvest treatments (pesticides, irradiation, coatings, etc.) or certain packaging methods (plastic, Styrofoam, recyclables)?

25- Exports. Is this commodity produced for export? What are the specific requirements for export (regulations of importing country with respect to grades, packaging, pest control, etc.)?

26- Marketing costs. Do handlers/ marketers have access to credit? Are prevailing market interest rates at a level that allows the borrower to repay the loan and still make a profit? Is supporting infrastructure adequate (roads, marketing facilities, management skills of staff, communication systems such as telephone, FAX, e-mail services)? What are the costs of any proposed change in marketing practices?

Annex 2: Wholesale data collection worksheet

WHOLESALE DATA COLLECTION WORKSHEET

Name of Data Collector:

Variety (if known _____) or describe color, shape, etc.

OFSP

Code: Wholesale _____

Questions and observations	on Arrival		at the time of sale	
Date				
name of market				
location of market				
Season for sweetpotatoes (range of sales dates in this market)				
Distance from farm if known	_____ km			
Sorting - selecting out that produce which will not be resold	Was sorting done before delivery? Yes/No	If Yes, estimate waste (discarded) _____% Reason for sorting out:	Was sorting done before sale? Yes/No	If Yes, estimate waste (discarded): _____% Reason for sorting out:
Was curing done at this market? (leaving the crop exposed to warm moist air for a few days until harvest wounds heal)			If yes, estimate weight loss: _____%	
Size Grading : is there any grading into different sizes on the farm?	If Yes, estimate % in each category: Large _____% ; Medium _____% ; Small _____%		If Yes, estimate % in each category: Large _____% ; Medium _____% ; Small _____%	
Does price offered vary by quality grade?	Describe grading criteria:		If Yes, what is the price offered for each quality grade? Highest _____ ; Middle _____ ; Lowest _____	
Expected wholesale price:			Price range _____ (by weight? By Volume? By Number of containers?) Price per kg: _____	
MEASUREMENTS	on Arrival		at the time of sale	
Sample size (select random samples)	count of 20		one package (_____ = total number)	

Time from harvest if known		
Time of day		
Air temperature	_____ C	_____ C
Relative humidity indicator	Wet bulb T: _____ Dry bulb T : _____	Wet bulb T: _____ Dry bulb T : _____
Pulp temperature in °C (3 randomly selected sweet potatoes)		
Quality sort for defects, decay, damage (# out of count of 20) Ratings from 5= Extreme defects, decay or damage; 3 = moderate; 1 = none	Number of rating 5 _____ Number of rating 3 _____ Number of rating 1 _____	Number of rating 5 _____ Number of rating 3 _____ Number of rating 1 _____
number with obvious defects ie: cracks, sunburn, misshapen, shrivel, over-mature, darkening etc		
Describe defects found (take photos)		
	on Arrival	at the time of sale
number with decay symptoms ie: fungus, mildew, bacterial spots, rot, etc		
Describe decay found (take photos)		
number damaged ie: bruises, cuts, mechanical injury, insect damage		
Describe damages found (take photos)		
Quality rating: 5= large 3 = medium size 1= small	Number Large size _____ Number medium size _____ Number small _____	Number Large size _____ Number medium size _____ Number small _____
Rate package protection	_____5 = very strong, protective	_____5 = very strong, protective

(mark one with an X)	____4 = strong, moderately protective ____3 = somewhat strong, protective ____2 = weak, not very protective ____1 = no pkg or very weak, no protection	____4 = strong, moderately protective ____3 = somewhat strong, protective ____2 = weak, not very protective ____1 = no pkg or very weak, no protection
Describe package or container: Type, material, dimensions, cooling efficiency		
Size and/ or weight of package or container		
Weight loss (set aside an initial random sample, weigh it again at time of sale)	Initial weight of sample	Weight at time of sale

% are calculated by #/20 or weight/total weight of sample or count/total count of sample

Annex 3: On-Farm Data Collection Worksheet

ON FARM DATA COLLECTION WORKSHEET

Name of Data Collector:

Variety (if known _____) or describe color, shape, etc

OFSP

Code Farm _____

Questions and observations	At Harvest	Farm gate
Date		
Location of farm		
Size of farm		
Crops produced		
Season for sweet potatoes (range of harvesting dates on this farm)		
Name of destination market if known		
Distance to market if known	_____ km	Expected journey time _____ hours

Sorting - selecting out that produce which will not be sent to the market	Was sorting done at harvest? Yes/No	If Yes, estimate waste (discarded) _____% or left in the field _____% Reason for sorting out:	Was sorting done before farm gate sale? Yes/No	If Yes, estimate waste (discarded): _____% Reason for sorting out:
Curing - is curing done before sale? (leaving the crop in a heap in the field after harvest to allow harvesting wounds to heal)			If yes, estimate weight loss: _____%	
Size Grading : is there any grading into different sizes on the farm?	If Yes, estimate % in each category: Large _____% ; Medium _____% ; Small _____%		If Yes, estimate % in each category: Large _____% ; Medium _____% ; Small _____%	
Does price offered vary by quality grade?	Describe grading criteria:		If Yes, what is the price offered for each quality grade? Highest _____ ; Middle _____ ; Lowest _____	
Expected farm gate price:			Price offered _____ (by weight? By Volume? By Number of containers?) Price per kg: _____	
MEASUREMENTS	At Harvest		Farm gate (to be measured again if possible)	
Sample size (select random samples)	count of 20		count of 20	
Time from harvest	0 hour			
Time of day				
Air temperature	_____ C		_____ C	
Relative humidity indicator	Wet bulb T: _____ Dry bulb T : _____		Wet bulb T: _____ Dry bulb T : _____	
Pulp temperature in °C (3 randomly selected roots)				
Quality sort for defects, decay, damage (# out of count of 20) Ratings from 5= Extreme defects, decay or damage; 3 = moderate; 1 = none	Number of rating 5 _____ Number of rating 3 _____ Number of rating 1 _____		Number of rating 5 _____ Number of rating 3 _____ Number of rating 1 _____	

number with obvious defects ie: cracks, sunburn, misshapen, etc		
Describe defects found (take photos)	Harvest	Farm gate (to be measured again if possible)
number with decay symptoms		
Describe decay found (take photos)		
number damaged ie: bruises, cuts, mechanical injury, insect damage		
Describe damages found (take photos)		
Quality rating: 5= large 3 = medium size 1= small	Number Large size _____ Number medium size _____ Number small _____	Number Large size _____ Number medium size _____ Number small _____
Rate package protection	____5 = very strong, protective ____4 = strong, moderately protective ____3 = somewhat strong, protective ____2 = weak, not very protective ____1 = no pkg or very weak, no protection	____5 = very strong, protective ____4 = strong, moderately protective ____3 = somewhat strong, protective ____2 = weak, not very protective ____1 = no pkg or very weak, no protection
Describe package or container: Type, material, dimensions, cooling efficiency, etc		
Size and/ or weight of package or container		
Weight loss on farm (set aside an initial random sample, weigh it again at time of sale)	Initial weight of sample	Weight at time of sale

% are calculated by #/20 or weight/total weight of sample or count/total count of sample
Citrus color at full ripe is dependent upon the variety, and could be bright

yellow, orange or green

Annex 4: List of Interviewees

1	MUZUNGU Daniel	Gasabo District	788564733	12-Jan-17
2	MUKAMANZI Liberathe	Rulindo District		12-Jan-17
3	MUSANABERA Fortunée	Rulindo District	783581354	12-Jan-17
4	UWAMA HORO Angélique	Rulindo District	782100695	13-Jan-17
5	AKIMANISHATSE Faustin	Rulindo District	07888555666	13-Jan-17
6	NDAGIJIMANA Félicien	Rulindo District		13-Jan-17
7	SHUMBUSHA Damien	RAB	0732800572	12-Feb-17
8	KANKUNDIYE Lydie	RAB	732800515	12-Feb-17
9	Musabyimana Aloysie	RAB	732351897	12-Feb-17
10	MUKASINE Jane	Gakenke District	788951599	16-Feb-17
11	KANZIGA Clementine	Gakenke District	786288521	16-Feb-17
12	MUSABENDE Hélène	Gakenke District	789833758	16-Feb-17
13	DEMBE Morgan	CIP	788783142	18-May-17
14	ISHIMWE Yvette	CIP	783508911	18-May-17
15	MUNYANEZA Jean Bosco	Gakenke District	780248837	31-May-17
16	NYIRANSENGIMANA Beatrice	Gakenke District	787879918	31-May-17
17	NSHIMYIMANA François	Gakenke District		8-Jun-17
18	MUKANEZA Léocadie	Gakenke District		9-Jun-17
19	KAYITESI Immaculée	CIP	786407362	9-Jun-17
20	Nshimiyimana Jean Claude	CIP	788500053	18-May-17

Annex 5: List of Districts visited

SN	Name of District
1	Rulindo
2	Gakenke

3	Muhanga
4	Gasabo

Annex 6: List of Tools for The Field

- The Oseri Pronto digital scale operates on 2 AAA batteries, has a capacity of 1.0 gram to 5,050 grams, with a tare feature. It weighs 300 grams and measures 8.2 x 1.8 x 6 inches and comes with a one-year warranty. It has received a 4.5 star Amazon rating (5.0 max) from 9,669 purchasers.
- The Camry Luggage Scale has a capacity of 50 kg, and is suitable for weighing crates of produce. It has a tare function and operates on one 3v lithium battery cell CR2032. It weighs 7180 grams. It has received a 4.5 star Amazon rating (5.0 max) from 283 purchasers.
- The Taylor Precision Waterproof Digital Thermometer Probe: with a range of -40 to 230 Celsius. It has a hold feature, allowing remote readings, and is fully waterproof. It is a pen-style instrument with a lanyard for easy field use. It has received a 4.0 star Amazon rating (5.0 max) from 9,669 purchasers.
- Tools for measuring wet bulb T using the digital thermometer probe: (for RH calculations): 10 cm of cotton gauze, tie to bind gauze to T. probe, water to saturate gauze, psychometric chart and instructions for how to use