EVERYTHING YOU EVER WANTED TO KNOW ABOUT SWEETPOTATO

TOPIC 8

Harvesting and Post-harvest Management

Reaching Agents of Change Training of Trainers (ToT) manual

October 2018

Building Nutritious Food Baskets

RAC Support Vitamin A Sweetpotato

CIP International Potato Center, A CGIAR Research Center

University of Greenwich

NRI | Natural Resources Institute

Helen Keller International

Orange-Fleshed Sweetpotato Rich in Energy & Natural Vitamin A

Everything You Ever Wanted to Know about Sweetpotato. Topic 8 - Harvesting and Post-Harvest Management
Reaching Agents of Change ToT Training Manual

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Topic 10: Marketing and Entrepreneurship. Reaching Agents of Change Training of Trainers (ToT) manual.	10.4160/9789290605027T10	Stathers, T., Low., J., Sindi, K., Ndyetabula, D., (2018). Everything You Ever Wanted to Know about Sweetpotato: Reaching Agents of Change ToT Manual. Topic 10: Marketing and Entrepreneurship. International Potato Center. Nairobi (Kenya). ISBN 978-92-9060-502-7. 41 p
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Contents

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This manual was originally produced as part of the Reaching Agents of Change project in 2013 and updated by the Building Nutritious Food Baskets project in 2017/2018 – both projects funded by the Bill & Melinda Gates Foundation.

Acronyms and Abbreviations

AIs	Adequate Intakes
AVRDC	The World Vegetable Centre
BNFB	Building Nutritious Food Baskets
CBO	Community Based Organisation
CIP	International Potato
DAP	Days After Planting
DFE	Dietary Folate Equivalents
DONATA	Dissemination of New Agricultural Technologies in Africa
DVM	Decentralised Vine Multipliers
dwb	Dry Weight Basis
FAO	Food and Agriculture Organisation of the United Nations
FW	Fresh Weight
HH	Household
HKI	Helen Keller International
IBPGR	Bioversity International
IPM	Integrated Pest Management
IPPM	Integrated Pest & Production Management
K	Potassium
LGA	Local Government Areas
M&E	Monitoring and Evaluation
MAP	Months After Planting
m.a.s.l.	Metres Above Sea Level
Mm	Mass Multiplication
MSC	Most Significant Change
N	Nitrogen
NARO	National Agricultural Research Organisation
NGO	Non-Government Organisations
NHV	Negative Horizontal Ventilation
NRI	Natural Resources Institute
OFSP	Orange-fleshed Sweetpotato
P	Phosphorous
PMCA	Participatory Market Chain Approach
PMS	Primary Multiplication Site
PPP	Public Private Partnership
PVC	Polyvinyl Chloride
QDPM	Quality Declared Planting Material

QDS	Quality Declared Seed
RAC	Reaching Agents of Change
RAE	Retinol Activity Equivalents
RCT	Randomised Control Trial
RDA	Recommended Daily Allowances
RE	Retinol Equivalents
REU	Reaching End Users
RH	Relative Humidity
SASHA	Sweetpotato Action for Security and Health in Africa
SMS	Secondary Multiplication Site
SP	Sweetpotato
SPCSV	Sweetpotato Chlorotic Stunt Virus
SPFMV	Sweetpotato Feathery Mottle Virus
SPKP	Sweetpotato Knowledge Portal
SPVD	Sweetpotato Virus Disease
SSA	Sub-Saharan Africa
ToT	Training of Trainers
TMS	Tertiary Multiplication Site
Tshs.	Tanzanian Shillings
TSNI	Towards Sustainable Nutrition Improvement
UNICEF	United Nations Children's Fund
USD	United States Dollar
Ushs.	Ugandan Shillings
VAD	Vitamin A Deficiency
WAP	Weeks After Planting
WHO	World Health Organisation
WTP	Willingness to Pay

Foreword

During the past decade, interest in sweetpotato in Sub-Saharan Africa (SSA) has expanded, the number of projects utilizing sweetpotato has increased, and the demand for quality training resources, training development practitioners and farmers has subsequently risen. Sweetpotato scientists at the International Potato Center and national research centres often received these requests and frequently held 1-3 day training sessions, drawing on whatever training materials they had or could quickly pull together.

The Reaching Agents of Change (RAC) project in 2011 changed that situation. Jointly implemented by the International Potato Center (CIP) and Helen Keller International (HKI), RAC sought to empower advocates for orange-fleshed sweetpotato (OFSP) to successfully raise awareness about OFSP and mobilize resources for OFSP projects. RAC also sought to build the capacity of public sector extension and non-governmental organizational personnel to effectively implement those projects to promote the dissemination and appropriate use of vitamin A rich, orange-fleshed sweetpotato. The Building Nutritious Food Basket (BNFB) is a three-year project (November 2015 to October 2018) that followed on from the RAC project. The project is implemented in Nigeria and Tanzania and funded by the Bill & Melinda Gates Foundation. The goal of the project is to accelerate and support scaling up of biofortified crops for food and nutrition security and to help reduce hidden hunger by catalyzing sustainable investment for the utilization of biofortified crops (OFSP, PVA maize, high iron beans and vitamin A cassava) at scale. BNFB develops institutional, community and individual capacities to produce and consume biofortified crops. The objectives of the project are to strengthen the enabling environment for increased investments in biofortified crops and to develop institutional and individual capacities to produce and consume biofortified crops.

RAC/BNFB goal of developing and revising the Training of Trainers (ToT) manual on *Everything You Ever Wanted to Know about Sweetpotato* was to see *sustained* capacity for training senior extension personnel about the latest developments in sweetpotato production and utilization in each of the major sub-regions of SSA: Eastern and Central Africa, Southern Africa, and West Africa. Hence, CIP identified local institutions to work with in Mozambique, Tanzania, and Nigeria to host an annual course entitled: *Everything You Ever Wanted to Know about Sweetpotato.* The course has progressed from initially having CIP scientists working closely with national scientists to implement it, to national scientists and partners independently organising and conducting the course. In subsequent years, institutions in Burkina Faso, Ethiopia, Ghana, Malawi and others have been capacitated in conducting the course.

In developing the course content, a long-time collaborator of CIP, Tanya Stathers of the Natural Resources Institute (NRI), University of Greenwich, worked with CIP Scientists to review the existing training material, added in new knowledge from sweetpotato scientists and practitioners, and designed the course with a heavy emphasis on learning-by-doing. The CIP personnel who contributed to the development of the initial manual include, (Robert Mwanga, Ted Carey, Jan Low, Maria Andrade, Margaret McEwan, Jude Njoku, Sam Namanda, Sammy Agili, Jonathan Mkumbira, Joyce Malinga, Godfrey Mulongo), Adiel Mbabu and HKI nutritionists (Margaret Benjamin, Heather Katcher, Jessica Blankenship) and an HKI gender specialist (Sonii David) as well as NRI colleagues (Richard Gibson, Aurelie Bechoff, Keith Tomlins). Some of the materials were adapted from the DONATA project training materials, the Reaching End Users project and many others. After practitioners had used the course and the manual, a review was held in 2012 and the manual and course were subsequently updated, and a standard set of accompanying Power Point presentations created. In 2017-2018, the Building Nutritious Food Baskets project led a further review of the manual working closely with Tanya Stathers, the above mentioned CIP teams again plus Robert Ackatia-Armah, Kwame Ogera, Srini Rajendra, Julius Okello, Fred Grant, Joyce Maru, Hilda Munyua and Netsayi Mudege to update the content of topics 3, 4, 5, 12 and 13 which cover: sweetpotato varietal selection; nutrition; seed systems; monitoring, learning and evaluation; and using the 10 and 5 day ToT course.

This manual is designed to potentially serve a wide variety of audiences (nutritionists and agronomists, policymakers, extension workers, community development workers, leaders of farmer organizations, farmers etc.). Not all the materials will be relevant to all audiences, but facilitators can adapt the content to their audience and facilitation best practices. To ensure sustainability and wide reach; a cascading approach in the delivery of training is recommended; where key experts (agriculturalists, nutritionists, health workers, marketing and gender experts) will attend more detailed ToT workshops. The experts trained will then become primary facilitators and drive the agenda for OFSP. This group will in turn deliver shorter version courses and step-down the training to various levels of audiences (secondary and tertiary) – based on needs identified. This trend will continue until the training cascades down to "farmer trainers" who finally train the end users in their communities.

The original version of the manual has also been translated into Swahili, French, Portuguese, and Amharic are available online at https://www.sweetpotatoknowledge.org/learn-everything-you-ever-wanted-to-know-about-sweetpotato/ with the intension of translating the revised chapters as soon as resources permit. We envision the course to continue to be improved as new knowledge comes in. In this way, we expect the vibrant and knowledgeable sweetpotato community of practice to continue to grow in the coming years. The *Everything You Ever Wanted to Know about Sweetpotato* course will help us to achieve the major objectives of the Sweetpotato Profit and Health Initiative (SPHI). Launched in October 2009, the SPHI seeks to improve the lives of 10 million sub-Saharan African families in 16 countries by 2020 through the diversified use of improved sweetpotato varieties.

Jan W. Low, Leader of the Sweetpotato for Profit and Health Initiative, International Potato Center
October 2018, 2nd edition.

How to Use This Guide

This guide was designed to be used in two ways:

- As self-study material, or
- As a facilitator's guide for classroom training sessions

For each topic we have provided:

- A handbook (this volume)
- A PowerPoint presentation, and
- A handout for classroom training participants

If you plan to deliver this as classroom training, then we would encourage you to read the **Facilitator's Guide** (separate volume) prior to planning your lessons.

Introduction: Harvesting and Post-Harvest Management

Topic Objectives

Topic 8 focuses on harvesting and post-harvest management. When you have completed this topic, you should be able to:

- Discuss harvest timing and prolonged harvests in detail.
- Describe the harvest process.
- Explain the process of packing, curing, and transporting sweetpotato.
- Strategize post-harvest handling for market.
- Navigate gender and diversity issues in sweetpotato harvesting and handling.
- Design and facilitate learning-by-doing activities around sweetpotato harvesting and handling.

Synopsis

Topic 8 focuses on the physical damage caused during harvest and transport, potentially reducing the shelf-life and value of sweetpotato roots. Over-drying and prolonged storage can reduce the beta-carotene content of dried orange-fleshed sweetpotato products. Good postharvest handling and storage practices for dried products are discussed, and methods for curing and storing fresh roots to increase their quality, value and availability are presented.

Unit 1 – Prolonging the Sweetpotato Harvest

Objectives

By the end of this unit, you should be able to:

- Explain why sweetpotato harvest is a flexible process.
- List the pros and cons of a prolonged sweetpotato harvest.

Key Points

- **Because sweetpotato does not have to be harvested all at once, the crop can create household food stability through a prolonged harvest.**
- **Many farmers harvest piecemeal to take advantage when the market outlook is favourable.**
- **Piecemeal harvesting can improve pest management by increasing the amount of attention farmers pay to vulnerable roots.**
- **Depending on the area, a prolonged harvest may raise the risk of weevils or theft by people or monkeys.**
- **Staggered planting and use of varieties with different maturing rates further lengthen the harvest season.**
- **Learning to preserve fresh sweetpotato creates opportunities to sell the roots at a high price during the dry season.**

Prolonging the Sweetpotato Harvest

Sweetpotato is a fairly flexible crop in terms of its harvesting time. Many farmers use a piecemeal approach to harvesting sweetpotato, whereby when roots are required by the household for food or for small-scale marketing just a few are dug up from a number of plants, and the remaining roots of these plants are then recovered with soil and left to continue bulking. This enables the roots to remain in the field until required and elongates the supply period to the house or markets.

However, mature roots become more vulnerable to theft by humans and monkeys, so in some areas this strategy may not be sensible. Piecemeal harvesting can help with better pest management, as if the field is being regularly visited for piecemeal harvesting the farmers will likely check the field for cracks or exposed roots and fill cracks and replace the soil over any protruding roots that they don't harvest. By filling the cracks and recovering any remaining roots the farmers are helping to prevent weevils from accessing the sweetpotato roots and the roots from being damaged by exposure to the sun.

The growing of several different varieties with different maturing periods, and the staggering of the planting time (e.g. so different portions of the field are planted every few weeks as planting materials become available) can also increase the fresh root harvesting period. However, despite the increased flexibility afforded by piecemeal harvesting practices and use of a mixture of varieties and staggered planting times, in many parts of Sub-Saharan Africa with prolonged dry season there is still a long period of the year when no sweetpotato roots can be harvested.

Unlike cassava crops, whose roots can be left in the field until required, if sweetpotato roots are left for too long in the field during the dry season, they typically get heavily attacked by weevils that access the roots via cracks in the soil as it dries out. Most people prefer to eat sweetpotato roots that have been freshly harvested as opposed to using reconstituted sun-dried pieces of sweetpotato.

This highly seasonal supply of fresh sweetpotato roots hinders the increased consumption of sweetpotato and the income earning opportunities for sales of fresh roots and for sweetpotato processing and products.

Farmers have developed ways of preserving freshly harvested sweetpotato roots to try and access the higher market prices paid for fresh sweetpotato roots during the off season (these are described below in the unit, *Managing Fresh Storage of Sweetpotato Roots*).

Review Questions

1. What are some advantages of prolonging the sweetpotato harvest?
2. What are some of the disadvantages?

Unit 2 – When and How to Harvest

Objectives

By the end of this unit, you should be able to:

- Discuss optimal harvest timing.
- List the criteria for deciding when to harvest.
- Describe best harvest practices.
- Calculate the probable yield of a field that is ready for harvest.

Key Points

- **While the harvest can be prolonged, there are criteria for harvesting particular sweetpotato plants and individual storage roots.**
- **These criteria range from market prices, labour availability, and the onset of pests to weather conditions or the need to clear the field for another crop.**
- **Typical plant maturity falls between 3-8 months.**
- **Harvesting too early or late can reduce the yield.**
- **Sweetpotato skin is delicate, and care must be taken not to wound the roots while harvesting. This can allow disease to enter roots, and it leaves a cosmetic scar that will reduce market value.**
- **Mechanical harvesting carries more risk of wounding the roots.**
- **"Curing" the roots by cutting away the vines a couple of days before harvest can thicken their skin and reduce wounds.**
- **Although piecemeal harvesting causes underestimation of yields, it is generally agreed that it increases yields by leaving more space for unharvested roots to grow.**
- **To best negotiate with traders when harvesting an entire sweetpotato field at once, farmers can learn to calculate the field's probable yield.**

When and How to Harvest

As described above, sweetpotato roots can be harvested over a period of several months, either piecemeal style (taking a few roots from each plant and then leaving the others to continue developing) or by harvesting different portions of the field or different varieties at different times.

The time of harvest of sweetpotato roots is therefore determined by:

- The variety's maturity period and its capacity for prolonged harvest;
- The environmental conditions (soil condition, weather, water supply etc.);
- Pest and diseases incidence;
- Market demand and price;
- Need to use the field for planting the next/ consecutive crop;
- Economic value of the next/ consecutive crop;
- Labour availability.

Sweetpotato roots are typically ready for harvesting between 3 and 8 months after planting. Some of the earliest maturing varieties are ready 3 months after planting, while other varieties are normally ready from 4.5 - 5 months after planting.

Manual harvesting of sweetpotato

Low yields can result if the crop is harvested too early or too late. If too early, the storage roots will not have had enough time to develop to their maximum size. If too late, the storage roots may have

become fibrous or have been attacked by weevils or root rots. However, other factors such as immediate need for food, cash or land may be bigger priorities than the amount of lost potential yield.

Sweetpotato roots have thin, delicate skin that is easily damaged by cuts and abrasions. Harvesting is typically done manually using sharp sticks, machetes or hand hoes, and farmers need to take care to avoid wounding the roots during harvesting. When sweetpotato roots are wounded during harvesting they not only then have an inferior appearance which can affect their market value, but diseases are also likely to enter through the wounds and cause rotting.

Harvesting of a whole field at once is likely to happen only if the sweetpotato is all being targeted to the market, and farmers will then typically harvest using a hand hoe. When piecemeal harvesting, particular care is taken not to injure the roots which will remain on the plant to bulk for longer.

Some farmers piecemeal harvest one area of their field, and completely harvest another area, depending on what they wish to do with the roots. In order to help protect the roots from damage, the vines can be cut off the plants up to 2-4 days prior to harvesting. This pre-harvest curing practice causes the skins of the roots to become firmer, making them less vulnerable to bruising during harvesting (see *Pre-Harvest and Post-Harvest Curing* for further details).

Working out the yield of your field

- Dig up at least 10 plants randomly selected from across your field and weigh the roots from each of them.
- Record the weight of roots for each plant. E.g.
- Then calculate the average weight of roots per plant. To do this, add up all the weights you recorded and then divide by the number of plants you sampled. E.g. 22kgs / 10 plants= 2.2kg/plant.
- To work out the yield of your whole field. Count how many plants there are in your field and multiply that number by the average yield (e.g. average yield = 2.2kg in this example). So if you had 4,000 sweetpotato plants in your field, you would multiply 2.2 x 4,000. You can then estimate that your field has 8,800 kgs of sweetpotato roots in it.

If harvesting for home consumption it is often women who do the harvesting and they will typically harvest just enough roots for a couple of days' meals. Different varieties respond differently to piecemeal harvesting; some produce larger or smaller roots as a result of it, while some have a longer time period during which piecemeal harvesting can occur. Varieties with longer maturity periods are usually more suitable for piecemeal harvesting than varieties with short maturity periods where all the storage roots tend to mature at the same time. Piecemeal harvesting can go on for a period of nine months depending on the variety, demand and pest pressure. But in dry conditions is unlikely to last for so long as the plants tend to dry up due to the disturbance of the root system and weevil pressure is high. Varieties with roots that form deeper down in the soil can typically be left for longer in the ground.

Due to the extended harvesting period which occurs when farmers practice piecemeal harvesting, the yield of sweetpotato fields is often underestimated. It is much easier for farmers or researchers to accurately assess the yield of a field when all the roots are harvested at the same time and can then be weighed and recorded immediately. However, studies have shown that piecemeal harvesting maximizes yields, as when mature roots are removed, space is created for expansion of the remaining roots.

Roots are typically carried home in baskets as head loads, or in sacks on bicycles, or by ox-carts.

Depending on the intended use of the harvested roots, they are sorted manually by shape, colour, size, damage levels etc. This can occur in the field or homestead or at the market. The harvested sweetpotato roots should be protected from direct sunshine as this can cause shrinkage and shrivelling. It is important for development workers to understand the roles played by men and women in sweetpotato post-harvest activities; so that training and activities can be effectively targeted to those doing the activity and can also involve those with influence over decisions or resources affecting the activities.

Sometimes traders will arrange to purchase a whole field of sweetpotato roots, they will often estimate the yield, agree on a price with the farmer and then bring their own labourers and transport and harvest the whole field at once. If farmers are to optimise their income from such arrangements, they need to be able to calculate the likely yield of the field before it is harvested. This can be done by digging up at least ten plants across the field (not just in one corner) and weighing each plant's roots, and then multiplying the average weight of roots per plant by the number of plants in the field (refer to the box above) and then multiplying that kg amount by the per kg current price of roots. If the trader is buying fields of different varieties, then the above calculation should be done for each variety, as they will differ significantly. If farmers are accurately able to estimate the weight of the roots on each plant after they have dug them up, they can then use these estimates to work out the average weight of roots per plant, and then multiply this by the number of plants in the field.

Where very large-scale commercial sweetpotato production is done such as in USA, Japan and China, the roots are harvested mechanically, usually shortly after the vines have been removed. The field rows are usually ploughed with a modified disk or moldboard plough with a spiral attachment. The roots are moved to surface of the soil and then collected by hand.

Mechanical harvesting can damage sweetpotato roots, and if the roots are left in the field for more than 30 minutes in hot sunshine they may be scalded by the sun and develop purplish-brown areas and become more susceptible to rots during storage.

Review Questions

1. What are some of the factors to consider when deciding on the optimal harvesting time?
2. What are some of the recommended best practices for harvesting?

Unit 3 – How to Safely Pack and Transport Fresh Sweetpotato Roots

Objectives

By the end of this unit, you should be able to:

- Explain best practices for packing and transporting sweetpotato roots.
- Identify bad packing practices.

Key Points

- **Sweetpotato roots should be kept in the shade after harvest.**
- **Sweetpotato must be packed with care, with the heaviest roots on the bottom.**
- **Overfilling and underfilling sweetpotato sacks both cause damage.**
- **Plastic or wooden crates or cardboard boxes work better than sacks.**

How to Safely Pack and Transport Fresh Sweetpotato Roots

Sweetpotato roots intended for market are typically packed into sacks in the field after they have been harvested. The unpacked and packed roots should be kept in the shade to maintain their quality. The roots should not be thrown or stepped on as they damage easily.

While packing, farmers often strategically place the largest roots at the top of the sack to attract buyers. To avoid root quality deterioration, care should be taken not to physically damage the roots during packing or transport. While sacks should not be overfilled, they also should not be underfilled as vibration can cause abrasions on the roots due to them moving against each other. Good aeration is also important.

Although sacks are the main packaging used for sweetpotato roots in most parts of Sub-Saharan Africa, roots can easily be damaged when packed in sacks particularly when the sacks are overfilled as is common.

Ideally, farmers should carefully pack their harvested sweetpotato roots into plastic or wooden crates or cardboard boxes to help reduce damage during transport. These containers should not be overfilled as this then prevents proper stacking and will damage the excess roots.

Care should also be taken during transport of the packed roots, whether by head load, bicycle, ox-cart, or truck. Market traders in Nairobi and Kampala typically try and sell all their sweetpotato roots within 3-4 days after arrival before rotting occurs.

Packing sweetpotato roots in wooden or plastic crates or cardboard boxes can reduce damage during transport

Review Questions

1. What are some of the best practices for packing and transporting OFSP?
2. What are the causes of damage during packing and transportation?

Unit 4 – Pre-Harvest and Post-Harvest Curing

Objectives

By the end of this unit, you should be able to:

- Describe best practices for curing sweetpotato, pre- and post-harvest.

Key Points

- **Sweetpotato quality declines soon after harvest.**
- **Rot can enter sweetpotato skin wounds caused during harvest.**
- **Removing foliage 2-4 days before harvest is pre-harvest curing and prevents wounding.**
- **Post-harvest curing consists of exposing the sweetpotato roots to temperatures of 25- 30°C and high humidity for 4-7 days further toughens the skin.**

Pre-Harvest and Post-Harvest Curing

Sweetpotato roots can be easily damaged during harvest. While this does not matter so much for those fresh roots which are to be consumed immediately, it does however have serious consequences for roots that are to be marketed or stored as rots can easily enter the roots through the wound sites, and root weight loss is more rapid.

Fresh sweetpotato roots are perishable, and even if undamaged their quality declines rapidly after harvest because they lose water and weight during storage which adversely affects their taste and texture, they can also be attacked by diseases such as root rots, and existing insect pest infestations can cause serious damage.

Pre-harvest In-ground Curing

A process commonly used with root and tuber crops to heal wounds, protect them against disease, reduce shrinkage and extend storage. By removing the foliage (dehaulming) of sweetpotato plants up to 2-4 days before harvesting, the post-harvest root losses can be significantly reduced and the shelf-life increased.

Post-harvest Curing

Happens by exposing the harvested sweetpotato roots to moderate temperatures of 25- 30°C and high humidity (90-95% RH (relative humidity)) for 4-7 days, a toughening of the skin of the roots occurs, which helps protect the root from damage and heal any existing wounds reducing the risk of post-harvest disease infection. In India, a research institute developed a method of in a well-ventilated place covering the freshly harvested roots with a polythene sheet raised ~15-20cm above the layer of roots. The polythene sheet was removed each night. Several days of this curing process led to increased shelf life of the sweetpotato roots and dramatically reduced fungal infection. In the USA after harvesting and grading, sweetpotato roots are typically cured by keeping them at ~30°C and 85-95% RH for 5-7 days, they are then put into storage warehouses at 12.5-18°C until they are needed for marketing. In commercial operations in South Africa, roots are washed, dipped in a fungicide, then air-dried prior to curing.

Review Questions

1. How is pre-harvest curing conducted?
2. How is post-harvest curing conducted?

Unit 5 – Managing Fresh Storage of Sweetpotato Roots

Objectives

By the end of this unit, you should be able to:

- Describe the development of practices for managing fresh sweetpotato root storage.
- Explain why fresh storage is underused in Sub-Saharan Africa (SSA).
- Describe several economical technologies for cool sweetpotato root storage.

Key Points

- **Supplying fresh sweetpotato to the market (as opposed to dried product) during the off-season can fetch very good prices in SSA.**
- **However, new storage methods for sweetpotato roots are not often used; sweetpotato is bulky and many growers perceive that the price differential does not often make it worthwhile.**
- **However, studies show that these new methods may in fact provide substantial profit increases.**
- **Pit stores and clamp stores are economical ways of keeping sweetpotato fresh for the off-season, at least for household use.**
- **Zero energy cool chambers use evaporation to cool fresh roots and are also economical.**
- **Modern storage facilities offering negative horizontal ventilation (NHV) are recommended for sale crops.**
- **Pests, diseases, and the delicate nature, high respiratory rate, and high moisture content of sweetpotato contribute to rapid deterioration without proper storage.**

Managing Fresh Storage of Sweetpotato Roots

Fresh sweetpotato roots outside of the main harvest season fetch a much higher market price than sundried sweetpotato root slices or pieces. However, despite significant efforts to find effective ways of storing fresh sweetpotato roots so that they can be used at home or sold to the market over a longer period of time, there is very little use of these methods in Sub-Saharan Africa. Fresh sweetpotato roots are categorised as perishable because once detached from the plant, unless they are cut into small pieces and sun-dried they cannot be stored for long periods of time, unlike grain crops.

In Bangladesh, Vietnam and Nigeria freshly harvested roots are commonly stored in a heap on the floor inside the house or on a raised platform or shelves or suspended from the roof for periods of 2 to 4 months, and then used for household consumption. They are usually covered with paddy straw or dry grass, and in some places ash which helps prevent fungal decay (and probably weevil damage). Fires may also be lit near to them once or twice a week to help smoke fumigate the roots. However, high losses are experienced.

In the Philippines, fresh sweetpotato roots are sometimes stored in a 50cm deep trench, covered with sand and sheltered by a roof. Pit and clamp type stores (e.g. mounds of sweetpotato stored in grass lined pits, often sprinkled with wood ash, and covered with soil) have been used traditionally in some areas of India, Papua New Guinea, Malawi, Cameroon, Southern Tanzania, Northern Nigeria and Zimbabwe. In Malawi, the pits were typically dug underneath maize or groundnut granaries. In

India they are commonly dug in a corner of the house, lined and covered with paddy straw and then plastered with mud.

Researchers have used these traditional stores as the basis from which to try to develop improved fresh root storage. Uptake of fresh root storage is dependent on the expected root price difference between that at harvest time and that a few months later on. As sweetpotato roots are low value and bulky, a significant number would need to be stored in a relatively large pit to make it economical to do so. If out of season fresh root prices are high, farmers might invest in storing some fresh roots in a pit or clamp store. A cost benefit analysis of fresh root stores for home consumption in Uganda showed much higher rates of return than any other sweetpotato enterprise.

Some of the reasons a farmer might decide to store fresh sweetpotato roots include:

- So that the land can be made available for other crops;
- So that the family can eat fresh sweetpotato roots for a longer period after harvest;
- So that the 'fresh' roots can be sold for a higher price during the off season;
- To reduce the level of root losses to sweetpotato weevils;
- As an emergency food and cash supply during the dry season.

For successful fresh sweetpotato root storage, farmers must:

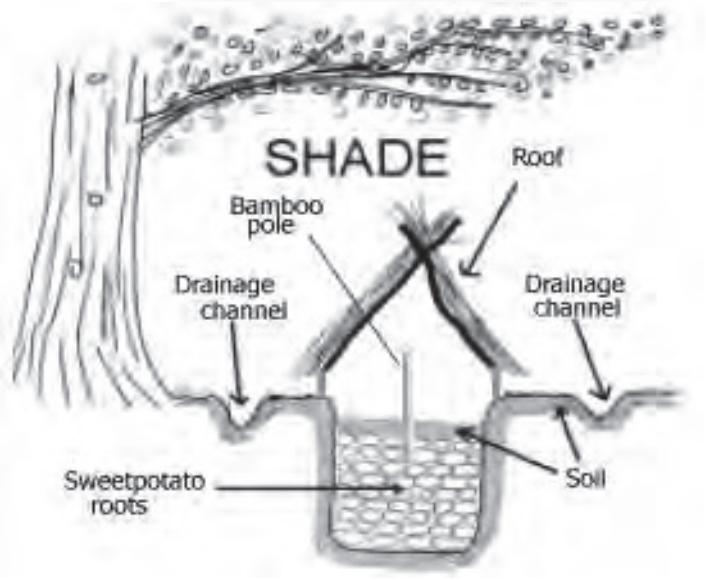
- Select only the top-quality roots without any signs of handling or pest or disease damage for storage. Damaged roots are much more susceptible to disease attack in storage which will then spread to the other roots.
- Keep the selected roots in specially designed stores (pit or clamp instructions are given below), and avoid temperature build-up in the stores, the stores should be carefully sited to ensure they are shaded from direct sunlight and cannot be flooded by rainwater. (Note: some studies suggest the store should not be lined with grass).
- Monitor the stores at regular intervals, every 1-2 weeks and check roots for rotting and insect or rodent damage. If roots become insect damaged or start to rot, remove all the roots from the store and discard them. If roots are undamaged, reseal and re-cover the store. Regularly check the roof structure and repair it as needed. As snakes are occasionally found inside the stores, care must be taken during inspections.

The two main types of stores used for fresh root storage by smallholder farmers are pit or clamp stores.

Pit Stores

To construct a pit store, a hole is dug in an area of dry ground. Whilst it is often recommended that the hole should be lined with dry grass to cushion roots from damage and absorb moisture helping to prevent roots from rotting, other studies suggest it is important not to line the pit with grass- so you may wish to experiment with both methods. Place roots carefully into the pit, cover completely with more dry grass (if you are using it) and then seal with dry soil up to normal ground level. A bamboo pole should be carefully inserted through the soil above the roots to act as a ventilation pipe. Ensure that its top end is high enough above ground level to reduce the chances of weevils crawling down it. Cover the pit with a raised sloping roof to shade the pit store and protect it from rain that could cause rotting. The size and shape of the hole depends on the number of roots to be stored. Add a drainage channel around the store to divert rainwater.

Pit stores can be used again the following season, but they must be sterilized before being re-used to prevent any carry-over of pests or diseases. They can be sterilized by lighting a fire in them. New grass and fresh soil should be used for lining and covering them each year. Farmers can also experiment with different sizes and shapes of stores, and in locating them in different places, and using different sweetpotato varieties to find out which combinations work best for them. If any problems with rotting were encountered, the farmer should build a new pit store in a drier position or alter the depth and size of the existing one and dig a drainage ditch around it. If insect pests were encountered, more careful selection of the roots is needed, and the store could be covered with a thicker layer of soil.

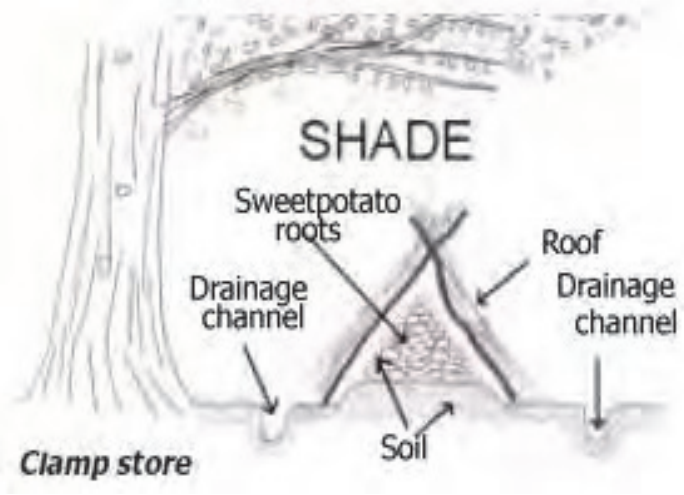


Pre-harvest in-ground curing (e.g. removal of all foliage up to 2-4 days prior to harvest) has been found to lead to improved root quality during pit storage of these roots.

Whilst theoretically the storage of fresh roots should enable farmers to sell them into the market during periods when the root price is high, in Tanzania most of the farmers involved in testing the pit stores used the stored roots for home consumption, saying that local market traders may not be keen on selling stored roots. This highlights the importance of involving traders and consumers in the development of such strategies.

Clamp Store

The clamp store should be made on a flat mound of earth raised about 10cm above ground level. Cover the flat mound (~1m wide) with dry grass for cushioning and to absorb moisture (note: you may wish to experiment with and without the dry grass layer). Carefully pile undamaged sweetpotato roots on top, then cover with more dry grass and then with a 10-20cm thick layer of dry soil. Cover the structure with a thatched roof to protect it from sun and rain, allow a gap all the way round between the roof and mound for ventilation. Add a drainage channel around the store to divert rainwater.



Clamp stores can be used again the following season, but they must be sterilised before being re-used to prevent any carry-over of pests or diseases. They can be sterilised by lighting a fire on them. New grass and fresh soil should be used for lining and covering them each year. Farmers can also

experiment with different sizes and shapes of stores, and in locating them in different places, and using different sweetpotato varieties to find out which combinations work best for them.

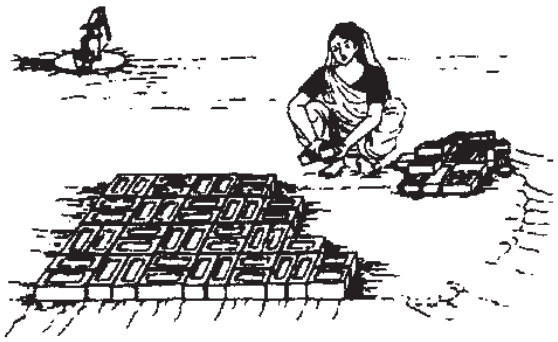
Zero Energy Cool Chamber

Zero energy cool chambers typically stay 10-15°C cooler than the outside temperature and maintain about 90% relative humidity. They can be built out of locally available materials such as brick, sand, bamboo, straw and sacks (see the figure below for step-by-step instructions). They depend on cooling by evaporation and do not require electricity. As water evaporates it has a considerable cooling effect and the faster the rate of evaporation the greater the cooling. Evaporative cooling occurs when air, which is not already saturated with water, passes over a wet surface. The technology works best when the humidity of the surrounding air is low. Very dry low humidity air can absorb a lot of moisture and so considerable cooling can occur. When the surrounding air is already saturated with moisture, no evaporation can take place and no cooling then occurs.

Zero energy cool chambers are being promoted in India and are seen as a promising technology for improving the shelf-life and supply of fresh sweetpotato roots as well as other fruits and vegetables in Sub-Saharan Africa.

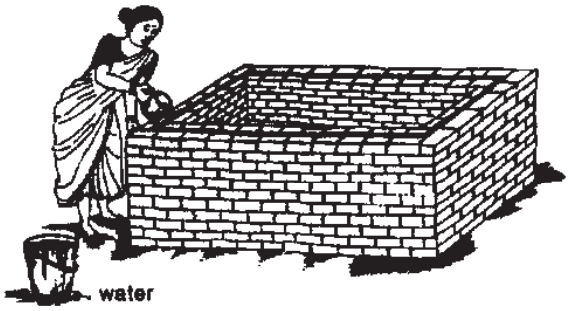
The development and introduction of post-harvest sweetpotato technologies needs to understand the current and likely future roles played by men and women in order to ensure that the technologies and tools are appropriate, and to recognise any gender impacts of introductions of new technologies and knowledge.

Constructing a Zero Energy Cool Chamber

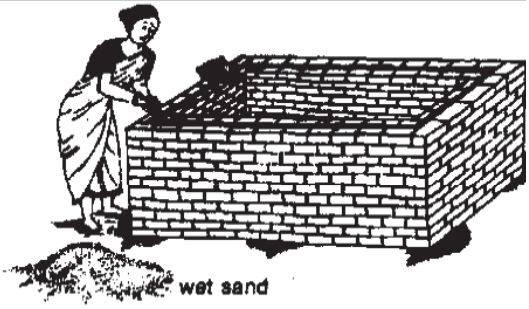


1. Select a raised site close to a source of water, where the breeze blows.
2. Make a floor with clean unbroken porous bricks.

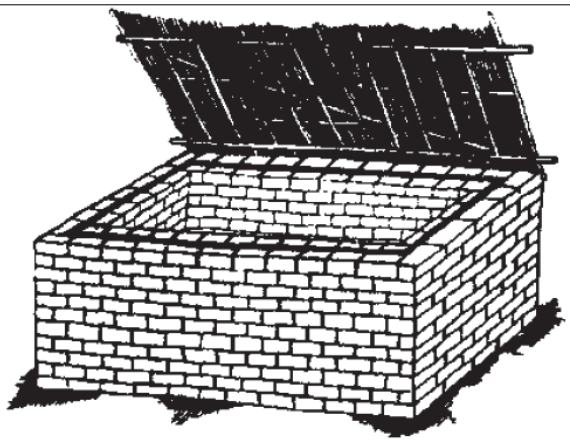
3. Erect a double wall 70 cm high, leaving a c of 7.5cm wide between the two walls

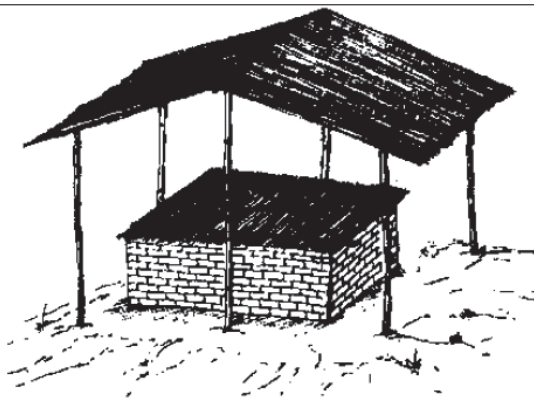


4. Drench the chamber in water



5. Soak fine, clean river-bed sand with water
6. Fill the cavity between the double wall wit this wet sand





Modern Large-Scale Storage Facility

A modern properly built storage facility maintains the temperature and humidity required for curing and long-term storage of sweetpotato.

A storage unit with negative horizontal ventilation (NHV) is recommended. The NHV system uses a slight negative pressure to pull the ventilation air horizontally past the pallet bins.

Mount fans internally along the top of a plenum wall on one end of the room to create the negative pressure. Air first enters the mass of sweetpotato at the end of the room opposite the plenum wall. Air then moves horizontally through the sweetpotato bins/crates toward openings in the plenum

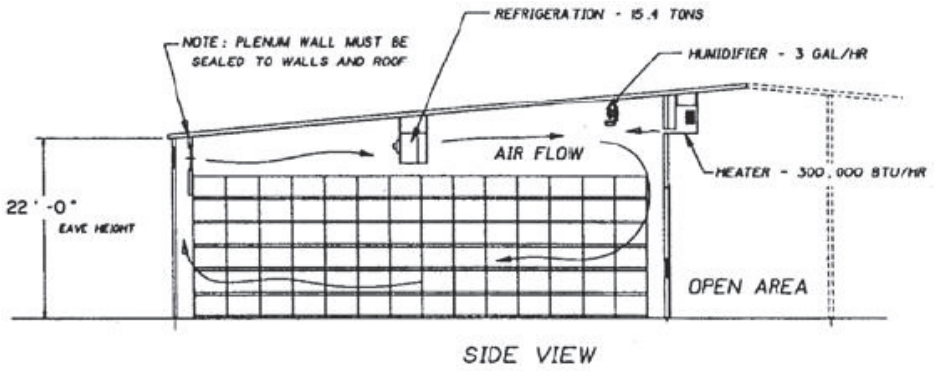
External and internal view of a modern NHV sweetpotato store in USA.

wall. Once in the plenum, the air rises and passes through the fans and back out into the room, where it moves horizontally in the opposite direction back over the top of the stacked bins.

The NHV system allows good air mixing, so there is little internal variation in temperature or humidity throughout the room. For the system to operate properly, the pallet bins must be placed tightly together, in straight rows, with as little space between bins as possible.

A series of motorized dampers are located on the exterior wall across the plenum from the fans. While these dampers remain closed, only internal air is circulated through the pallet bins. These dampers are opened when outside air is required for ventilation or cooling. Air is pulled into these openings because of the slight negative pressure the fans create in the plenum. The size and number of these dampers are determined by the capacity of the room. When correctly designed, approximately one-third of the air passing through the fans will be pulled from outside, with the remainder of the air recirculated from the stack of pallet bins. The air displaced by the incoming air exits the room through gravity shutters located near floor level at the end of the room opposite the plenum.

Instructions for constructing a NHV store are given in the report by Edmunds et al., 2008.



Side view of a construction diagram for a negative horizontal ventilation (NHV) store

Effect of Fresh Root Storage on Beta-Carotene Content

Few studies have been done on the retention of beta-carotene during fresh root storage. However, in contrast to processed sweetpotato roots, the beta-carotene in the stored fresh roots is protected from external factors, and therefore the content is typically maintained. It has been noted that depending on the timing of the harvest, the temperature and humidity, and the variety the beta-carotene content in some roots slightly increases and in others decreases. In general, fresh storage does not affect the beta-carotene levels significantly.

Causes of Post-Harvest Losses in Fresh Sweetpotato Roots

Fresh sweetpotato roots are highly perishable due to their high moisture content (60-70%), sugar content (4-15%), delicate thin skin, their high respiratory rate immediately after harvest which produces heat and leads to softening of the roots. Shelf life varies by variety. Leaving the harvested storage roots in the sun for a short period is believed to help increase shelf-life but can also lead to increased moisture loss and softening.

Physical causes of post-harvest losses include:

Mechanical Damage - Cuts, skinning, and bruises are usually caused during harvesting, transport or marketing.

Cracking - Cracking is often caused by soil nematode damage.

Chilling - Cold wet soils or subsequent exposure to temperatures below 13°C result in tissue breakdown and souring of the root flavour.

Physiological causes of post-harvest losses include:

Respiration - Respiration contributes to weight loss of the roots and altered appearance; wounding can increase the respiration rate and weight loss. Varieties with high dry matter content have less weight loss following harvest. Respiration rate is higher at higher temperatures.

Sprouting - If roots are stored at high temperature and humidity, sprouting happens very quickly.

Biological causes of post-harvest losses include:

Pests - The sweetpotato weevil (Cylas spp.) is a serious field and post-harvest pest of sweetpotato. Weevil feeding damage not only causes unsightly holes in the roots but also causes a bitter taste and unpleasant smell to develop in the roots.

Diseases - Fungal and bacterial rots (often gaining access through wound sites on roots due to harvesting or weevil damage or through infected planting materials) result in soft and sunken areas developing on the roots and may cause the roots to taste bitter. There are a wide number of different rots each with specific symptoms.

Root rotting

Rodent damage

Cylas weevil damage

Review Questions

1. What are the traditional methods for OFSP storage?
2. What are the advantages of zero energy cool chamber?

Unit 6 – Enhancing Market Value of Fresh Sweetpotato Roots Through Improved Post-Harvest Handling

Objectives

By the end of this unit, you should be able to:

- Discuss the series of processes that best prepares sweetpotato roots for market.
- Identify good packaging practices to add value for market.
- Explain which transportation practices are best and why.

Key Points

- **Washing, sizing, grading, packaging, and transportation are essential handling steps in getting sweetpotato to market.**
- **Sweetpotato should be gently rinsed, not scrubbed. Adding a small amount of an antimicrobial agent avoids decay.**
- **Sweetpotato roots should be hand sorted to remove bad product, using gloves to protect the skins and to protect workers from fungicides.**
- **Sacks are a poor transport choice. Avoiding the use of sacks reduces losses and ensures best market value.**
- **Packaging properly adds cost but reduces losses.**

Enhancing Market Value of Fresh Sweetpotato Roots Through Improved Post-Harvest Handling

Washing

When the fresh sweetpotato roots are ready to be taken to the market, their value can be enhanced by improving their presentation through washing. This should be a rinsing as opposed to a physical scrubbing which will damage the skin. A gentle rinsing should be sufficient to remove the loose soil on the roots. To reduce rinsing related decay, the grower can add a small amount of an antimicrobial agent such as sodium hypochlorite (liquid bleach) to the rinsing water.

Grading and Sizing

After rinsing to remove the soil, the sweetpotato roots should be sorted by hand to remove any rotting or otherwise unmarketable roots. Workers who directly handle roots could wear gloves to protect roots from fingernail scratches and human pathogens and also protect workers from any fungicides or other chemicals which may have been used to preserve the roots.

Though grading and sizing is not commonly done in most parts of Africa, growers, wholesalers and retailers should be encouraged to practice roots sizing. Sorting sweetpotato into uniform sizes should be a key function of packing and improving the value of the product in the market.

Packaging

Proper packaging is an important step in the journey from the grower to the final consumer. Packing and packaging materials will add some significant cost to the price of the final product. However, if it is done to target different consumers it can add value and help to differentiate the product from other commonly marketed sweetpotato roots. Much of the root wastage which occurs in the market and the associated complaints are due to inappropriate packaging. Across most of Sub-Saharan Africa, sweetpotato is packed and transported to market in large sacks that are heavy to carry and

hence, often dropped. This causes bruises and other mechanical damage to the roots which encourages rotting and reduces the storage and shelf-life of the roots and may discourage consumers from purchasing sweetpotato roots. Pre and/or post- harvest curing can help reduce root damage (see Pre-Harvest and Post-Harvest Curing)

A significant percentage of buyer and consumer complaints can be traced to inferior container design or inappropriate container selection and use. A properly designed sweetpotato container will contain, protect, and identify the sweetpotato, satisfying everyone from grower to consumer. The container must enclose the sweetpotato roots in convenient units for handling and distribution. It must protect the sweetpotato roots from mechanical damage and environmental conditions during handling and distribution. The container or packaging should identify and provide useful information about the contents. Provision of information such as product name, brand, size, grade, cultivar, net weight, count, fungicide treatment, grower, shipper, and country of origin adds value in the eyes of the consumer. When marketing orange-fleshed sweetpotato roots it is also important to include nutritional information, and even recipes and other useful information directed specifically at the consumer.

This labelling can help growers and others in the value chain keep track of the source of the roots as well as the shipping destination. Traceability is the ability to follow a piece of produce from the grower through to the consumer and enables the source of any problems to be easily identified and then dealt with.

Transporting Quality Roots

Transporters should avoid using sacks to pack and carry sweetpotato. The thin delicate skin of sweetpotato roots means they are easily bruised during transportation if packed in sacks and particularly so if the sacks are overfilled and the roads are bumpy. It is recommended that wooden or plastic pallets which can be stacked on top of each other are encouraged. This will lower root losses and improve the shelf life of the roots. As the importance of sweetpotato increases, growers, brokers, truckers, and receivers need to become well informed regarding the specific handling requirements of sweetpotato in order to reduce losses and improve quality.

Examples of High-Tech Post-Harvest Handling of Sweetpotato Roots as Used in the USA

Pouring sweetpotato roots into water using a fork-lift mounted bin rotator device

High volume water rinse used to clean sweetpotato roots

Workers grading roots

Fungicide application using a waterfall curtain

Automatic box fillers integrated into electronic sizing equipment

Cardboard box packaging

Bulk bins for transporting roots to processors

Branding on sweetpotato packaging & Packages

Source of images: Edmunds et al., 2008

Review Questions

1. What are some of the practices for post-harvest handling?

Unit 7 – Managing Dried Chip Storage of Sweetpotato Roots

Objectives

By the end of this unit, you should be able to:

- Explain how slices and small pieces of dried sweetpotato root are produced and used in parts of SSA, both traditionally and commercially.
- Identify best practices for handling sweetpotato roots in dried chip storage.
- List the steps and best practices for creating well-preserved, home-dried sweetpotato products.

Key Points

- **Commercial processing of dried sweetpotato root products in SSA is increasing, including flour and chips.**
- **Sun-drying destroys beta-carotene, but good drying management can reduce the loss to under 35%.**
- **Over drying should be avoided.**
- **Room-temperature storage in the long term creates extreme beta-carotene degradation.**
- **Cool temperatures and opaque containers are optimal.**
- **Dried sweetpotato root products should be consumed within about two months, for nutrient retention and to limit pest damage.**
- **Opaque polypropylene sacks are best for dried sweetpotato chip storage.**
- **Flour should be stored in polythene.**
- **Containers should be cleaned between seasons and kept 1m off the ground.**
- **Parboiling, salting, and traditional additives such as ash can deter insects. Re-sun-drying can stop an insect infestation.**

Managing Dried Chip Storage of Sweetpotato Roots

In some parts of Sub-Saharan Africa, sweetpotato is traditionally sun-dried in slices or small pieces and then stored as a food stock for consumption during the rest of the year, with occasional small sales to local markets.

The dried sweetpotato pieces are typically rehydrated and used in stews or made into a mixed cereal-root porridge.

The processing of sweetpotato into dried chips and flour for use in locally sold commercial products is now increasing. The process used for making high quality dried sweetpotato chips and flour is given in the box to the right. Detailed information on processing is given in the topic, Marketing and Entrepreneurship.

During sun-drying, beta-carotene contained in the slices or chips of sweet potato is exposed to air (oxygen), temperature and light that are damaging to it. As a result, the beta-carotene can be destroyed. However, beta-carotene degradation can be limited to less than 35% loss through the use of good drying management.

Good drying management should ensure:

1. Chips or slices are regularly mixed or turned during drying (i.e. every 2 hours) so they don't over dry on one side;
2. The density of the chips spread on the dryer is not too great (about 4kg/m^2 for shredded sweet potato = chips);
3. Samples should be removed in the event of rain and placed in a dry place until drying conditions improve (e.g. sun shining again);
4. Samples are removed from the dryer as soon as they are dried – over drying is not good.

Storage of dried sweetpotato at room temperature for several months results in an extremely high degradation of beta-carotene (e.g. 70-80% loss from the initial dried products after 4 months).

Storage of dried sweetpotato is the main cause of beta-carotene degradation. In order to limit beta- carotene degradation the storage duration should be limited to no more than 2 months (the shorter the better for beta-carotene retention) and the product stored in a cool room (low temperature) and in closed/opaque containers. If possible, air should be excluded from the packaging, as this substantially increases the shelf life of the product, however it is not often possible because of the type of specific vacuum packaging then required.

Making High Quality Dried Sweetpotato Chips and Flour

1. Carefully select healthy fresh sweetpotato roots.
2. Clean and peel the roots.
3. Wash roots in clean water (a washing drum can be used in large scale production).
4. Pre-dry the roots on a clean surface in the sun for 10 minutes.
5. Cut the roots into slices about 5mm thick using a clean sharp knife (or into thinner chips, using a mechanised slicer or chipper for large scale production).
6. Sun-dry the slices on a raised tray.
7. The dried slices can then be stored in clean opaque polypropylene sacks or milled into flour and stored in opaque polythene bags.

Traditionally dried sweetpotato is stored in a range of structures including sacks in the house, woven and mud plastered granary baskets placed inside or outside the house.

Traditional granary used for storing dried sweetpotato chips

Whatever storage structure is used, it should be raised off the ground (on stones, bricks or a wooden pallet/ frame built from branches) to prevent uptake of ground moisture into the stored sweetpotato, and to allow air to flow around it. If a pallet is not available, sacks should be stacked on a plastic sheet. Storage sacks should not be allowed to touch the walls of a store room, and the sacks should be stacked carefully to prevent collapse. Bag stores are convenient for many reasons; they can be easily removed for consumption, sales, inspection, or a further sun-drying, or in case of an emergency (fire, flooding etc.). But they are also conveniently packed for easy theft, so should be kept somewhere secure.

If a woven or brick granary structure is outside, a thatched roof should be placed over it to protect it from rain and sun. Mud plastering of woven baskets helps to protect them from insect entry and theft. Padlocking the doors of brick granaries is advisable. Ensure there are no overhanging branches of trees which rodents could use to access the stored product. If possible, a store should be raised to 1m above ground height, and rodent guards should be placed on the legs.

Drying sweetpotato

Good Storage Hygiene

No matter what storage structure is used, before loading the freshly dried sweetpotato slices, the structure should be thoroughly cleaned to remove all traces of last season's stored food and to reduce the likelihood of carryover of storage pests and diseases from one storage season to the next. Bags can be brushed clean and then if possible dipped into boiling water then hung up to dry in the sun. The area around the sacks or store needs to be kept clean, and clear of any household items which could provide hiding or breeding places or easy entry points for insects or rodents. Make sure the walls and roof of a store are also swept clean of any previous crop residues or insect life stages. Any cracks in the wall or floor of a store should be filled. Mud walls can be re-plastered each season to help ensure insects that are hiding in the crevices are not able to infest the new crop as soon as it is placed in the store. Some storage insects' pests can bore into the timber pole structures of a store, if you notice insect infestation of the timber in a store it is best to remove the infested timber and replace it with new timber as otherwise it will act as an easy source of re-infestation. The discarded wood should be burnt quickly to prevent the insects in it infesting new products.

Only Store Good Quality Products

Make sure the product you are storing is of a good quality. If any of the dried slices or chips look diseased or have recent insect feeding holes in them, discard them as they will otherwise act as a source of infestation while in storage. Remove any foreign matter e.g. stones, straw, dirt from the product to be stored as these materials will hold water and could cause the product to become mouldy during storage.

Regular Monitoring

Inspect the stored sweetpotato regularly for signs of any damage by insects or rodents (e.g. insect feeding dust, rodent droppings and spillages, distinctive smells), any rotting or dampness. If the signs are spotted early, action can be taken before the damage becomes severe.

Protecting Your Stored Commodity from Rodents

A good store should keep the product cool and dry, and protect it from rodents, birds, livestock and thieves; most stores do not manage to prevent insects from entering. If rodents become a problem in an indoor bag store, traps can be placed on the floor along the wall or in the corners, as rodents like to run along next to the edges. Rodent poisons can also be used but should be avoided if young children or livestock are present, as they are lethal to humans and farm animals. Rodent poisons should NEVER be placed in the stored food commodity as if any of it accidentally got mixed up with the stored sweetpotato it would poison the person who ate it. For outside stores, ensure there are

no overhanging branches of trees which rodents could use to access the stored product. If possible, a store should be raised to 1m above ground height, and rodent guards should be placed on the legs to prevent rodents from being able to access the stored commodity.

Protecting Your Stored Sweetpotato from Storage Insect Pests

A wide range of stored product insect beetle pests are known to attack dried sweetpotato and dried cassava. The adult beetles are <1cm in size, and often bore holes into the dried sweetpotato and then lay their eggs inside these holes. On emerging their larvae feed inside the dried sweetpotato pieces forming tunnels and greatly reducing the quantity and quality of the stored product. Signs of such infestation include small feeding holes on the sweetpotato chips and presence of insect feeding dust. Most storage insect pests take about a month to complete their lifecycle from egg to adult. So, if the dried sweetpotato is only going to be stored for a couple of months, pest damage is unlikely to be high.

Pest management practices should be implemented if the product is to be stored for longer than two months.

There are many practices which farmers can use singly or together to reduce storage insect damage to dried sweetpotato. These include:

Sun-drying

If insect pest damage is observed in the stored sweetpotato, it can be taken out of the store and re-dried in the sun. Make sure you place the dried sweetpotato on a clean mat, plastic sheet or tarpaulin, and that it is spread in a thin layer e.g. ~2cm thick. Leave it in the hot sun for a few hours, and the heat will destroy many of the developing pupae, larvae and eggs within the commodity. Make sure livestock cannot reach it. Re-drying the product at regular intervals during the storage season can help reduce the moisture content and insect infestation levels.

Parboiling

If the sweetpotato slices are par-boiled for 5 minutes before sun-drying, this will harden the resulting chips making them less attractive to storage insects. Alternatively, fresh sweetpotato roots can be boiled for 30-60 minutes prior to peeling, slicing and sun-drying.

Salting

Adding 20-30g of salt per kg of freshly sliced sweetpotato chips has been found to reduce insect storage pest attack.

Insect Proof Containers

Storing dried sweetpotato chips inside clay pots with sealed lids, can prevent insects from infesting the product as long as it was not already infested prior to storage.

Traditional Protectants

Ash and dried plant materials are often mixed in with stored products to help repel or kill insect storage pests. The removal of these materials can often be a big task though as large quantities are usually required for effective pest management and need to be removed before consumption. Some plant materials may be toxic to humans, and it is therefore important to make use of relevant practices and knowledge already existing in the community.

Review Questions

1. What are some of the best practices for sun drying chips to prevent beta-carotene loss?
2. What are some of the techniques for effective storage of dried chips?

Unit 8 – Gender and Diversity Aspects of Sweetpotato Harvesting and Post-Harvest Management

Objectives

By the end of this unit, you should be able to:

- Explain gender and diversity issues in sweetpotato harvesting and post-harvest management.
- Discuss sweetpotato harvesting and post-harvest roles in terms of gender and identity.
- Identify issues which may bar those with lower incomes from accessing preservation technologies.

Key Points

- **Access to preservation technologies and labour-saving devices is uneven across socio-economic groups and genders.**
- **Facilitators should consult both with members of the community who perform harvesting and post-harvest management activities, and those who direct matters and/or control resources.**

Gender and Diversity Aspects of Sweetpotato Harvesting and Post-Harvest Management

A thorough discussion of gender and diversity aspects in relation to sweetpotato is presented in the topic, Gender and Diversity Aspects. Key gender and diversity issues relevant to sweetpotato harvesting and post-harvest management include:

- Understanding sweetpotato harvesting and post-harvest roles and access to resources in the community.
- Building on the understanding of gender and diversity roles to ensure appropriate tools for harvesting, transporting the roots home from the field, or storing the fresh roots already exist or are being introduced or developed.
- Fresh root pit and clamp stores require significant labour to construct and maintain them. If those who would benefit from fresh root storage cannot access the required labour, these technologies may not be adopted.
- Manually chipping and drying sweetpotato roots is labour intensive; labour saving technologies exist but are they accessible to those typically involved in chipping and drying sweetpotato roots?
- As with all activities it is important to not only target those groups who will be involved in doing the focal post-harvest activity but also those who control the resources involved and who have a say in relevant decisions which affect the process including community leaders.

Activities

These learning-by-doing activities will provide hands-on discovery opportunities for participants.

Activity 8.1 Increasing Profits Through Storing Fresh Sweetpotato Roots

Objectives

Participants will be able to estimate the yield and value of a field of sweetpotato roots as well as:

- Understand good harvesting practices in order to minimise losses during harvesting and post-harvest;
- Know how to set up a pit store for fresh root storage, select undamaged roots to place in it, and be aware of the key fresh storage problems.

Time

2 hours

Materials

- Nearby sweetpotato field which is ready for harvest and where the participants can dig up 10 plants per group to work out the yield
- Scales;
- Sack;
- Calculator;
- Pen and paper;
- Spades;
- Hoes;
- Dry grass;
- Bamboo poles;
- Harvesting sticks;
- Branches;
- Thatching grass;
- String.

Advanced preparations

Identify or plant a nearby sweetpotato plot that the trainees can harvest in order to calculate yield.

Suggested steps

1. Ask the participants to work in groups of ~8 people. Explain to them that they will be visiting a field and will firstly have to estimate the yield of the field and harvest some roots which they will then use to set up either a pit or a clamp store in which they can store the fresh roots. Walk to the field.
2. Once at the field, remind them that in order to store fresh roots, the roots need to be undamaged, so they should be carefully while they are harvesting and weighing the roots of their plants.
3. Ask each group to work out the sweetpotato yield of the field, using the following method. They should then compare their findings between groups, and then discuss the current per kg price of this variety of sweetpotato and use that to calculate the value of the sweetpotato in the field.
4. Explain that each group can decide whether to construct a pit or a clamp store for storing their fresh sweetpotato roots. (The facilitator should however ensure that both types of

fresh root store are being constructed). Remind the participants that they should think
5. carefully about where they will site the store.

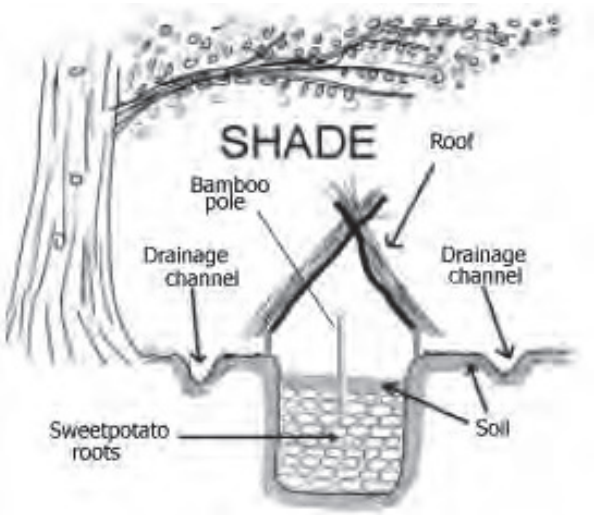
Working out the yield of your field prior to harvesting

- Dig up at least 10 plants randomly selected from across your field and weigh the roots from each of them.
- Record the weight of roots for each plant. (*see example below)*

1	2	3	4	5	6	7	8	9	10
1.2	2.3	2.6	3.0	2.3	1.7	2.0	2.3	2.7	1.9

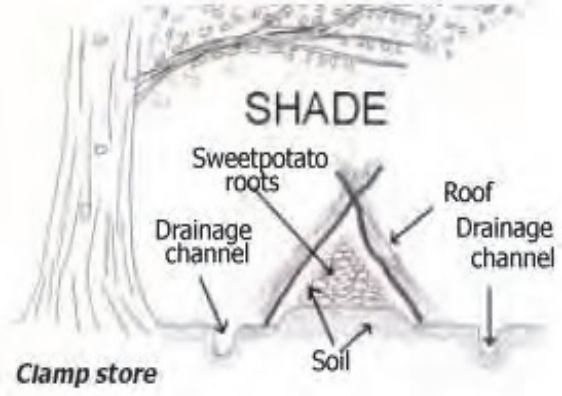
- Then calculate the average weight of roots per plant. To do this, add up all the weights you recorded and then divide by the number of plants you sampled. e.g. 22kgs / 10 plants= 2.2kg/plant.
- To work out the yield of your whole field. Count how many plants there are in your field and multiply that number by the average yield (e.g. average yield = 2.2kg in this example). So if you had 4,000 sweetpotato plants in your field, you would multiply 2.2 x 4,000. You can then estimate that your field has 8,800 kgs of sweetpotato roots in it.

Pit Stores



Hole dug in an area of dry ground. Whilst it is often recommended that the hole should be lined with dry grass to cushion roots from damage and absorb moisture helping to prevent roots from rotting, other studies suggest it is important not to line the pit with grass- so you may wish to experiment with both methods. Place roots carefully into the pit, cover completely with more dry grass (if you are using it) and then seal with dry soil up to normal ground level. A bamboo pole should be carefully inserted through the soil to act as a ventilation pipe, ensure that its top end is high enough above ground level to reduce the chances of weevils crawling down it. Cover the pit with a raised sloping roof to shade the pit store and protect it from rain that could cause rotting. Size and shape of hole depends on the number of roots to be stored. Add a drainage channel around the store to divert rainwater.

Clamp Store



Clamp store

This structure should be made on a flat mound of earth raised about 10cm above ground level. Cover the flat mound (~1m wide) with dry grass for cushioning and to absorb moisture (note: you may wish to experiment with and without the dry grass layer). Carefully pile undamaged sweetpotato roots on top, then cover with more dry grass and then with a 10- 20cm thick layer of dry soil. Cover the structure with a thatched roof to protect it from sun and rain, allow a gap all the way round between the roof and mound for ventilation. Add a drainage channel around the store to divert rainwater.

After the groups have looked at each other's' clamp or pit stores, facilitate a discussion regards the issues associated with fresh root storage (e.g. off-season market prices, rotting, need for undamaged roots, where to site the fresh root stores, monitoring of fresh root stores, re-use of fresh root stores).

Activity 8.2 Effect of Sun-Drying and Storage on Beta-Carotene Content of Orange-Fleshed Sweetpotato

Objective

Participants will understand how the processing and storage of OFSP affects it beta-carotene content

Time

30 mins

Materials

- 50 orange-fleshed sweetpotato roots;
- Chipping machine;
- Raised drying rack;
- At least 3 sample bags;
- Labels;
- Marker pens;
- Data set showing how beta-carotene content decreases with prolonged sun-drying;
- Sufficient photocopies of the data set showing how beta-carotene content decreases with prolonged storage.

Advanced Preparation

On the first day of the 10-day ToT course, prepare a small quantity of OFSP chips and place them out on a raised rack to sun-dry (this will become the 'sun-drying for 7 days sample'), on day 3 of the ToT course, chip some more OFSP and place it on the same raised rack but do not mix it with the first sample. Make sure the samples are clearly labelled and protected. On day 6 of the ToT course, chip some more OFSP and place it on the same raised rack to sun-dry, and ensure it is clearly labelled and not mixed with the earlier samples. On Day 9 of the ToT carefully collect the three samples (keep them separate) and take them into the training room and place them on a side table.

Suggested Steps

1. You will have chipped and sun-dried the different batches of OFSP in advance (see advanced preparation above). Carefully collect the three samples and keeping them separate carry them into the training room and display them on a side table, each should have a clear label that states how long they were sun-dried for.
2. Ask the participants to quietly observe the different samples, and then ask them to suggest what differences they saw between the samples and why they think these differences exist, and why they might be important.
3. If possible provide beta-carotene content estimates of the different samples and ask the participants what conclusion they can draw from this information and how does it affect sun-drying practices. (*Note: when chips of Ejumula variety were sun-dried for 1 day the beta- carotene loss was 10%, and after 3 days sun-drying it was 48% in Uganda*).
4. In addition to sun-drying, storage also affects the beta-carotene content. Provide the participants with beta-carotene content data from samples that were stored for different periods of time (see the Handout below). Give them a few minutes to study the data and discuss it with their neighbour and then ask them to explain what happens to the beta-carotene content over time and how temperature influences

this. Ask them to explain what implications this has for storage practice this information has (e.g. cool room, opaque packaging).

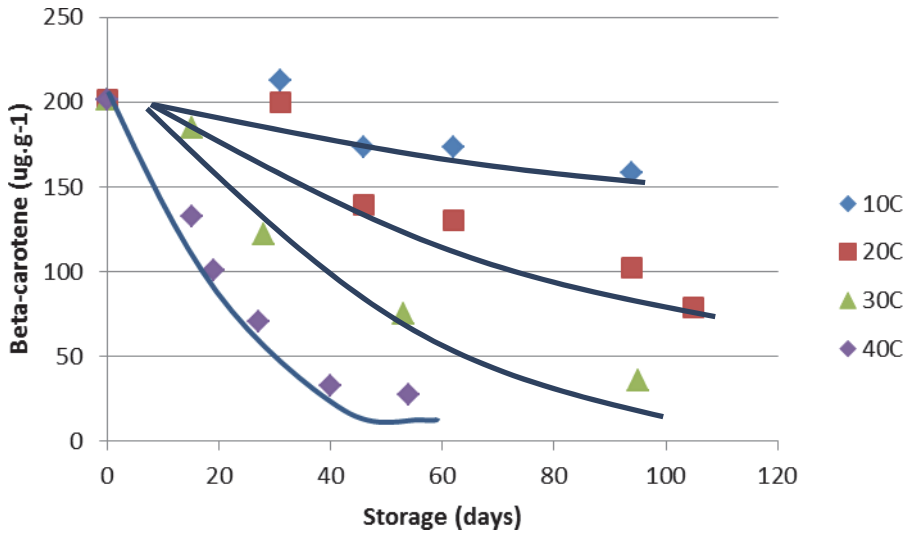
5. In summary draw out or explain that:
   - The key issue for beta-carotene retention in dried chips is storage period and not drying. "It doesn't matter how well you dry your sweetpotatoes, if you store them for four months, you will have lost your beta-carotene."
   - The initial beta-carotene level is also important: if you have little beta-carotene at the beginning, you will get less in the end product. If you have high levels at the start, then you will lose some, but still have enough beta-carotene at the end for the food to be nutritious.
   - Other quality issues can also occur during storage leading to off-smells, rancidity etc.

[Handout] Beta-carotene concentration of dried sweetpotato chips over different storage periods and at different temperatures.

Data set

at 10°C		at 20°C		at 30°C		at 40°C	
Storage (days)	*Average beta-carotene concentration (ug/g dwb)*	*Storage (days)*	*Average beta-carotene concentration (ug/g dwb)*	*Storage (days)*	*Average beta-carotene concentration (ug/g dwb)*	*Storage (days)*	*Average beta-carotene concentration (ug/g dwb)*
0	201.0	0	201.0	0	201.0	0	201.0
31	212.8	31	199.6	15	184.9	15	132.4
46	173.6	46	139.3	28	121.9	19	100.7
62	173.3	62	130.1	53	75.0	27	70.8
94	158.5	94	102.2	95	35.5	40	32.9
105		105	78.8			54	27.6

Logarithmic Degradation of Beta-Carotene During Storage of Dried Sweetpotato Chips of Ejumula Variety at 4 Different Temperatures



Answers to Review Questions

Unit 1

1. What are some advantages of prolonging the sweetpotato harvest?
   - *Crop can create household food stability through a prolonged harvest; Improving pest management by increasing amount of attention farmers pay to vulnerable roots; Opportunities to sell roots at high price during the dry season.*
2. What are some of the disadvantages?
   - *May raise risk of weevils; Theft by people or monkeys (dependent on area); In case of prolonged dry season, long time of year no OFSP roots can be harvested.*

Unit 2

1. What are some of the factors to consider when deciding on the optimal harvesting time?
   - *Variety's maturity period and its capacity for prolonged harvest; Environmental conditions (e.g. soil condition, weather, water supply etc.); Pest and diseases incidence; Market demand and price; Field use for planting the next/ consecutive crop; Economic value of the next/ consecutive crop; Labour availability.*
2. What are some of the recommended best practices for harvesting?
   - *Use sharp sticks, machetes or hand hoes; Curing - vines can be cut off 2-4 days prior to harvest; Avoid mechanical harvesting, if possible, as it increases potential for harm; Piecemeal: Harvest just enough for a couple days' meals.*

Unit 3

1. What are some of the best practices for packing and transporting OFSP?
   - *Keep roots in shade after harvest; Care to not physically damage roots during packing; Provide adequate aeration; Use plastic, wooden crates or cardboard boxes; Sell roots within 3-4 days to avoid rotting.*
2. What are the causes of damage during packing and transportation?
   - *Overfilling or underfilling sacks; rocks.*

Unit 4

1. How is pre-harvest curing conducted?
   - *Removing foliage (dehaulming), up to 2-4 days before harvesting.*
2. How is post-harvest curing conducted?
   - *Exposing the sweetpotato roots for 4-7 days to: Temperatures of 25- 30°C and High humidity.*

Unit 5

1. What are the traditional methods for OFSP storage?
   - *Pit, clamp.*
2. What are the advantages of zero energy cool chamber?
   - *Typically stays 10-15°C cooler than outside temperature; Maintains 90% relative humidity; Does not require electricity; economical technology; Studies show new methods provide substantial profit increases.*

Unit 6

1. What are some of the practices for post-harvest handling?
   - *Washing the roots; grading and sizing; proper packaging; proper transportation.*

Unit 7

1. What are some of the best practices for sun drying chips to prevent beta-carotene loss?
    - *Chips or slices are regularly (every 2 hours) mixed or turned during drying; Chip density spread on dryer is not too great (recommended 4kg/m^2); Remove from rain and place in dry area, return to dryer when sun returns; Remove from dryer as soon as dried to prevent overdrying.*
2. What are some of the techniques for effective storage of dried chips?
    - *Dried chips should be stored at cool temperatures; Storage duration should not exceed 2 months; Containers should be kept 1m off the ground and cleaned between seasons; Insect infestation should be prevented by: Parboiling, salting, and ash deter insects or Re-sun-drying,*

References

Ameu, M., Carey, E., (2011). TOT training manual on sweetpotato vine multiplication.

Bechoff, A., Westby, A., Menya, G., Tomlins, K.I., (2011). Effect of pre-treatments for retaining total carotenoids in dried and stored orange fleshed-sweetpotato chips. *Journal of Food Quality*, 34, 259– 267.

Edmunds, B., Boyette, M., Clark, C., Ferrin, D., Smith, T., Homes, G., (2008). Post-harvest handling of sweetpotates. North Carolina Cooperative Extension Service. 56pp. http://www.bae.ncsu.edu/people/faculty/boyette/pubs/sweetpotatoes_postharvest-1.pdf

Ezell, B.D. and Wilcox, M.S., (1952). Influence of storage temperature on carotene, total carotenoids and ascorbic acid content of sweetpotatoes. *Plant Physiology,* 27(1): 81-94.

IIRR (1996). Environmentally sound technologies for women in agriculture. 213pp. http://collections.infocollections.org/ukedu/uk/d/Jii01ee/4.4.html

Low, J., Lynam, J., Lemaga, B., Crissman, C., Barker, I., Thiele, G., Namanda, S., Wheatley, C., Andrade, M., (2009). Chapter 16 Sweetpotato in sub-Saharan Africa. In: The Sweetpotato. Loebenstein, G., Thottappilly, G., (Eds.). Springer. pp359-390.

NRI, LZARDI, TFNC, (undated). Storing sweetpotato made simple. 2pg leaflet. NRI, UK.

Omosa, M., (1997). Current and potential demand for fresh and processed sweetpotato products in Nairobi and Kisumu, Kenya. CIP, Lima.

Ray, R.C., Ravi, V., Hegde, V., Rajasekhara Rao, K., Tomlins, K., (2010). Chapter 2 Post harvest handling, storage methods, pests and diseases of sweet potato. In: Sweet Potato: Post Harvest Aspects in Food, Feed and Industry. R.C. Ray, K.I. Tomlins (Eds.). Nova Science Publishers, New York. 316pp.

Roy, S.R., (undated). Presentation on: On-farm storage technology can save energy and raise farm income. http://ucce.ucdavis.edu/files/datastore/234-2143.pdf

Smit, N., (1997). Integrated pest management for sweetpotato in Eastern Africa. Thesis (PhD), Wageningen Agricultural University, The Netherlands, 151pp.

Stathers, T., Namanda, S., Mwanga, R.O.M., Khisa, G., Kapinga, R., (2005). Manual for sweetpotato integrated production and pest management farmer field school in sub-Saharan Africa. CIP, Uganda. pp168+xxxi

Tomlins, K., Ndunguru, G., Kimenya, F., Ngendello, T., Rwiza, E., Amour, R., van Oirschot, Q., Westby, A., (2007). On-farm evaluation of methods for storing fresh sweet potato roots in East Africa, *Tropical Science*, 47, 197-210

Tomlins, K., Rees, D., Coote, C., Bechoff, A., Okwadi, J., Massingue, J., Ray, R., Westby, A., (2010). Chapter 10 Sweet potato utilization, storage, small-scale processing and marketing in Africa. *In*: Sweet Potato: Post Harvest Aspects in Food, Feed and Industry. R.C. Ray, K.I. Tomlins (Eds.). Nova Science Publishers, New York. pp. 271-293.

Wheatley, C., Loechl, C., (2008). A critical review of sweetpotato processing research conducted by CIP and partners in sub-Saharan Africa. CIP, Lima, Peru. Social Sciences Working Paper 2008-3. 48pp

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