Strategies for storage of orange-fleshed sweetpotato in Sub-Saharan Africa to ensure supplies for processing: Lessons learnt and the way forward

Fig 1. Sweetpotato crates loaded into Phase 1 store (Credit: A. Marchant)

SASHA Sweetpotato Action for Security and Health in Africa

- Two evaporatively cooled stores (Fig.1) with the capacity to each hold 5 tonnes of sweetpotato roots were constructed in Kenya, one run on mains power and the other on solar. Using the evaporative cooling system temperatures of 20-23°C were achieved and fresh sweetpotato storage trials kept 63-83 % of the roots of the variety Vita suitable for puree production relative to initial weight after 4 months of storage and 54-59% of the roots for the variety Kabode
- A solar-powered standard refrigeration store was constructed from a shipping container, air conditioner and Coolbot to achieve storage temperatures of 15°C and curing temperatures of up to 30°C and humidification
- Storage trials in this cooler store reduced sprouting and weevil infestation problems but suffered from higher rotting, with just 35-56 % of root material suitable for puree after 4 months
- De-haulming prior to harvest improved root storability
- Further work is needed to understand the impact of varietal differences, curing and storing conditions, air flow and air exchange rates in stores

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What was the problem?

The pronounced seasonality of sweetpotato production and prices, adverse weather conditions, and fluctuation in market-demand are just some of the challenges faced by the nascent orange-fleshed sweetpotato (OFSP) puree supply chain. Following promotion through SASHA2, OFSP puree is now being used by Kenyan supermarket chains for producing vitamin A-rich bread. A constant year-round supply of high quality OFSP roots is required to produce the OFSP puree. This constant supply can be achieved through a combination of staggered root production, purchase from different geographical areas, and the storage of fresh OFSP roots up to four months to cover periods of low supply. In the United States of America and in South Africa sweetpotato roots are stored for up to 10 months in sophisticated purpose-built stores. The ideal storage conditions are defined as 12.5 - 15°C with relative humidity of > 90%. At the start of storage, the roots are subjected to a curing phase at a higher temperature of 25-32°C under high relative humidity (>90 to 100%) for several days to one week to promote healing of wounds incurred during harvest. Under these conditions a storage life of 6-10 months can be expected, although sprouting can occur after about six months, depending on the cultivar.

What objectives did we set?

The objective was to achieve effective and economically advantageous commercial-scale solar-powered storage of fresh orange-fleshed sweetpotato roots for processing into puree, in a tropical area of sub-Saharan Africa (SSA).

Where did we work?

Fresh sweetpotato root storage trials were set-up using two types of stores at the Organi Ltd. sweetpotato processing plant in Homa Bay county, Kenya. Similar trials were undertaken later in the project in Mozambique.

What did we achieve during SASHA Phase 2?

Two designs of stores were constructed and tested; based on evaporative cooling in Phase 1 and using standard refrigeration technology in Phase 2.

Phase 1: Evaporative cooling storage

During Phase 1 two stores were constructed at Organi, in Homa Bay County in Kenya with temperature control based on an evaporative cooling system developed with low installation costs and low power demand (Fig. 2) to allow the use of an alternative power supply such as

Fig 2. Evaporative cooling system for cooling Phase 1 store (Credit: A. Marchant)

solar power, and using existing 12v components. These stores also had the capacity to provide heat in order to cure roots for four days at the start of storage. During the main storage period they were capable of cooling the stores to temperatures of 20-23°C. A horizontal air-flow system was used, and water was sprinkled on the store floors daily to increase humidity levels. Detailed storage trials were carried out on two consignments of roots (variety Kabode and variety Vita, washed and unwashed after harvest), with monthly monitoring of root status and processing quality. Roots lost weight due to water loss and respiration, and there were additional losses due to rots, sprouting and weevil infestation. Taking all of these factors into account, after four months storage 54-59 % (Kabode) and 63-83 % (Vita) of root material was suitable for puree production relative to initial weight.

Phase 2: Standard refrigeration storage

Given concerns about weevil infestation and development, levels of root sprouting, a new store was constructed at the same site in Phase 2 (Fig. 3), aiming to achieve storage temperatures closer to the commercial recommendations of 15°C. In this case a solar-powered store with the capacity to hold 81 crates or about 4 tonnes of sweetpotato roots (Fig. 4), was constructed. It was built using a converted freight container with temperature control based on a standard air conditioner

Fig. 3 Solar powered Phase 2 store (Credit: M. Precoppe)

Fig. 4 Sweetpotato crates loaded into solar-powered container store at trial set-up at Organi Ltd, Home Bay County, Kenya (Credit: T. Stathers)

controlled by the CoolBot system to achieve temperatures down to the required range (15°C), and heating to achieve temperatures of 28-30°C required for curing. Humidification was achieved using a water sprinkler situated at the top of the container and separated from the produce by an impermeable barrier to prevent wetting. As done for the phase 1 stores, a horizontal air flow system was used. Additional fans were installed to provide air exchange with the external environment and to prevent build-up of carbon dioxide. A store was also constructed to similar specifications in Mozambique.

Although the Kenyan Phase 2 store was able to maintain the target temperature and humidity levels, the overall expected improvement in quality of stored roots was not observed. Rates of fresh root weight loss were similar to loss rates in the Phase 1 trials, weevil infestation and sprouting were almost eliminated, but from after one-month of storage onwards the rates of rot development were higher. After four months, 35–56 % of root material was suitable for puree production relative to initial weight; with washing of roots prior to storage leading to lower amounts suitable for puree compared to unwashed roots in this trial. In addition, de-haulming (removing the vines 4-5 days prior to root harvest) led to higher amounts of well-stored roots compared to the normal harvest method. The trials conducted in Mozambique using smaller quantities of five varieties of research-station produced roots, with additional manual removal of roots with rots at each monthly sampling, had significantly lower levels of rot after four months.

The way forward: Factors to explore to reduce losses during fresh root storage

For fresh root storage to provide a practical strategy to support OFSP puree processors and potentially traders there are a number of factors that we want to explore further.

Quality of roots

In the phase 1 trials there was a very significant difference in the storability of the consignments of varieties Vita and Kabode. It is not possible to determine how much this

Fig. 5 Sorting and counting raw root during the 4 months storage sampling assessment at Organi Ltd, Home Bay County, Kenya (Credit: D. Omondi)

Fig. 6 Normal harvest unwashed roots after 4 months storage displaying the high incidence of rotting which occurred in this trial (Credit: B. Otieno)

is due to varietal differences and how much it is due to the growing conditions, harvesting practices etc, but this does give an indication of the impact of root quality. This may explain some of the differences between trial results in Kenya and Mozambique, for example we know that the roots from Mozambique were larger on average than those in Kenya.

Strategies for harvesting and handling of roots

Experts from the US have advised that to optimise sweetpotato storage, roots should be packed straight into boxes in the field and not handled again before storage. In the current African context, we do not consider this to be practical. In our trials the roots have been carefully handled and then sorted to remove any weevilled, damaged or small roots (Fig. 5). Given that processors will need to receive roots carefully harvested and handled by farmers, transported and then sorted prior to storage, the roots used in the Kenyan storage trials represent a realistic root quality for processor or trader storage. We do not anticipate that we can achieve a significant improvement in this stage of the handling process.

Use of preharvest de-haulming, and avoiding harvesting in the rains

We have demonstrated that de-haulming four days before harvesting had a significant positive effect on stored root quality, and we recommend de-haulming at 4 to 7 days prior to harvest should be included as standard practice for roots intended to be stored. This is only possible in dry weather, as in the rains this promotes sprouting. It also requires significant trust and/or contractual agreement between the farmers and processor.

Storage boxes

A short mid-storage trial was conducted to compare wooden and plastic boxes. In this small trial, no effect on storage quality was apparent. Wooden boxes have the advantage that they can be constructed to the optimum size and repaired as necessary and in the event of condensation do not pool water which acts as a reservoir for pathogens. Plastic crates are generally being used increasingly for handling and transport of fresh produce across Kenya and other sub-Saharan African countries, although sacks and baskets are still the cheapest and most common packaging used.

Curing conditions

The curing conditions recommended for sweetpotato in the USA are 25-32°C under high relative humidity (RH) (>90 to 100 %) for several days to 1 week. In these trials the conditions used were 28°C, 90% RH for 4 days. Given the high levels of rot, we should investigate whether the conditions we are using should be adapted. For example, it is possible that the promotion of rot growth at the high temperatures and humidities are more detrimental compared to the wound-healing process (Fig. 6). In small UK trials on air-freighted Kenyan sweetpotato roots (white/cream fleshed), we have demonstrated that curing is more effective at 90% RH than 80% RH and have preliminary indications of the advantages of curing in terms of reducing weight loss, reducing respiration and reducing rotting.

Air exchange rates

One difference between the trials in Mozambique and Kenya was that the density of root packing in the store was much greater in Kenya than Mozambique, to the extent that there was a build-up of carbon dioxide in one Kenyan trial up to 3 %. However, increasing air exchange to prevent carbon dioxide build up in subsequent storage trials appeared to have little effect on root quality deterioration during storage. Discussion with experts in the USA indicates that this is not really considered a problem. Nevertheless, in future trials we will test the effects of different air exchange rates.

Air flow rates within the store

One question is whether with the current Phase 2 store in Kenya condensation is occurring on stored roots and promoting rotting, and whether this would be reduced by higher rates of air flow. The storage technicians saw no significant visible signs of condensation, but in the future more detailed checks will be necessary.

A parallel set of trials are being set up at NRI UK to investigate the effect of air flow rates on stored sweetpotato roots using simulation trials that will consider airflow past individual roots and across simulated boxes.

Were there any key challenges or lessons learned?

One key lesson learnt is that even when transferring a well-established technical solution from one place to another, it is important to test it at a small-scale first to ensure it works in the different context (i.e. with the different root varieties, handling practices, growing and environmental conditions). The small-scale system needs to enable multi-treatment trials to be conducted, for example to compare different curing or storage temperatures or humidities. For the storage trials conducted during this project we were hampered by the fact that we could not directly compare the effect of changes in storage conditions. The storage life of the produce depends critically on its initial quality which changes between trials. In future projects there need to be at least two storage chambers constructed, following preliminary practical studies on a smaller-scale.

Secondly, when farmers obtained their OFSP vines from decentralized vine-multipliers they did not record which OFSP variety they obtained, and thus after the Phase 1 trial it was not possible to compare the effect of variety on storability as the two varieties Vita and Kabode cannot be clearly visually distinguished.

Fig. 7 High quality OFSP roots after 4 months storage in Kenya (Credit: T. Stathers)

What's next?

In the description above we have identified several factors to be investigated to increase storage life and reduce losses. NRI is undertaking simulated trials in the UK to start this investigation, and we will be seeking opportunities to carry out future trials in Kenya.

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