

THE
MCKNIGHT
FOUNDATION

COLLABORATIVE
CROP RESEARCH
PROGRAM

POSTHARVEST HANDLING MANUAL

*for Maize, Millet, Sorghum,
Sweet Potato and Cassava*

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Introduction

Maize, millet, sorghum, sweetpotatoes and cassava are the major crops grown and consumed in Uganda. However, most of the food produced is lost postharvest (20-30%), mainly due to poor postharvest handling methods, including late harvesting, poor harvesting and sorting methods, insufficient drying, inappropriate storage conditions, poor processing, use of defective packaging, and infestation by molds, insects and rodents. This manual gives guidelines on post-harvest practices and technologies that can be used to maintain quality and reduce losses in maize, millet, sorghum, cassava and sweetpotatoes handling.

MAIZE

a) Harvesting

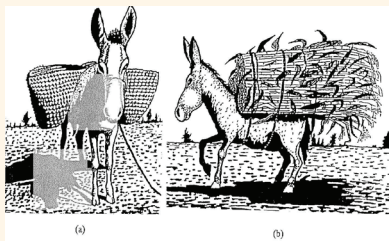
- Harvest when mature (leaves should be yellow, stems of plants are brownish and yellow).
- Avoid damage by birds, pests, rodents and wild animals. This can be done by avoiding extensive field drying
- Avoid breakage of grain- while harvesting, gently pile the cobs to minimize damage to grain
- Before harvest, check maize cobs for insect infestation.
- Harvest before the rains, this causes rewetting of grains which could lead to mold growth
- Put the harvest cobs on a tarpaulin or off the ground while harvesting



b) Transportation from the field

- Place the harvest in bags or containers during storage to prevent spillages e.g. nylon bags (not torn), jute bags without holes and well covered baskets
- The containers in which grain is carried should be clean to prevent contamination of grain

- During transportation, care should be taken to avoid grain damage, breakage and spillage.
- The laborious transportation of carrying on heads or backs can be reduced e.g. by use of bicycles, wheel barrows, carts and draught animals like donkeys

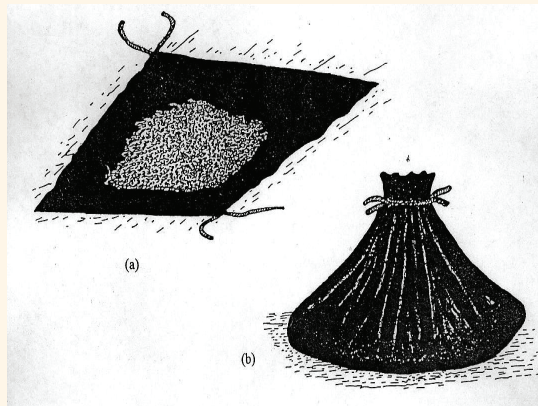
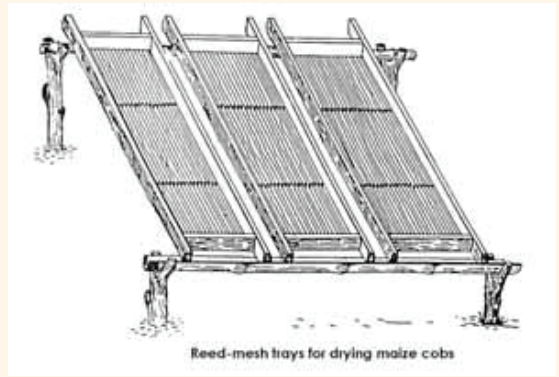
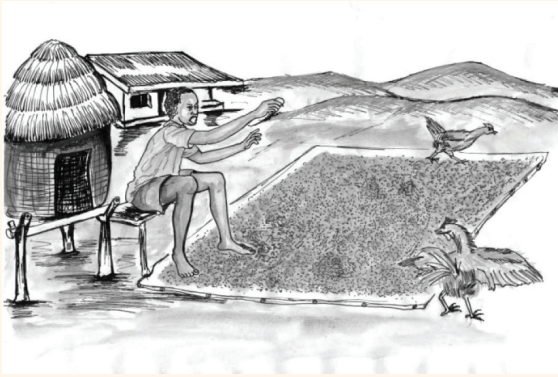


c) Drying

- Clean the drying surface thoroughly before spreading the grain for drying to prevent contamination with dirt, other foreign matter
- Grain should not be dried on bare ground. Simple drying facilities e.g. mats, heavy-gauge polythene sheets, tarpaulins, mesh trays, drying racks can be used- preferably drying on waterproof black polyethylene sheet/ tarpaulin hastens the drying process, because it absorbs heat.
- Drying should be done preferably on raised platforms to minimize contamination by dust, insects and losses due to animals.
- The product should be spread thinly (about 2 cm thick) to hasten the drying process.
- For safe storage and processing, the grain should be dried to at least 13% moisture content- *a moisture meter is the most effective method to detect moisture content, however, biting and other traditional methods can be used*

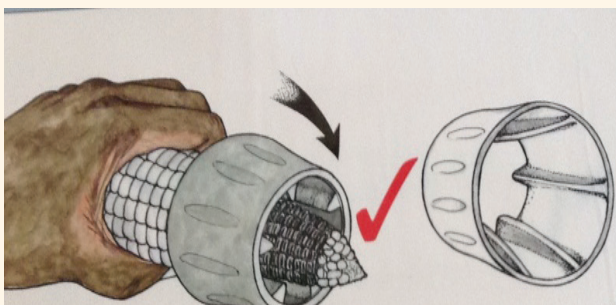


- Preferably, the dried grain should be stored appropriately immediately to minimize contamination, insect attack, rodent attack, moisture pick up and subsequent mold growth
- The crop needs to be moved under shelter (inside the house or veranda) or covered completely with water-proof material e.g. polyethylene sheets when rain threatens or during night fall or one could wrap in waterproof sheet to protect from the rain



d) Shelling

- Shelling should not be done on bare ground to prevent losses due to spillages and contamination
- Hand shelling though laborious causes less grain damage than stick beating
- Alternatively, one can use a hand sheller or a power sheller
- Shelled grain should be put into clean spillage-proof containers or preferably bags





e) Cleaning and grading

- Proper cleaning should be done to entirely remove foreign matter, extraneous matter, insect damaged, etc and facilitate grading
- Thorough cleaning ensures high storage quality of grain and low storage losses
- Cleaning can be done using manual sorting or by use of screens
- Proper sieving and grading helps farmers to attract buyers and capture better prices



f) Pre storage grain treatment

- Ensure that where the grain is being treated is clean (preferably concrete floor)
- Mix four heaped match boxes per bag (100kgs) if using 1% actellic dust as disinfectant
- Where affordable, wear protective clothing (gloves, gumboots)
- Ensure proper packaging and sewing of the bag after treatment.

g) Storage

- Remove old grain from the store 5-6 weeks before harvest.
- Fumigate the store with pesticides before bringing in grain after removing the old grain
- Keep grain clean, dry and cool. This prevents losses due to moisture pick up, mold growth, quality deterioration and insect attack.
- Keep storage structure clean, dry and well ventilated.
- Have adequate rodent proofs e.g. rat guards on the stands of grain stores or use cats and breeding sites for rodents to prevent losses due to rodent attack
- Use storage facilities that prevent moisture pick up, insect/pest attack e.g. locally fabricated metallic silos, triple bags or ventilated cribs (for unshelled maize).
- Bags or containers with grain should be stacked on pallets and off the walls (about 1 m away) to prevent moisture pick up



h) Milling

- Mill dried grains to fine flour if it is meant for flour
- The surfaces of a milling machine in contact with the product should be made from stainless steel
- Preferably, it is important to pass at least 3-5 kg of the product to clean the system before milling the whole batch. This prevents contamination of the flour

i) Collective bulking

- Collective marketing is recommended. Working together helps to reduce costs of handling and assembling.
- Collective marketing attracts more buyers and improves income.

MILLET AND SORGHUM

a) Harvesting

- Like for maize, millet should be harvested once fully mature. At this point, the leaves are brownish and entire plant starts to dry
- Cut the head slightly below the inflorescence or the end of the stem at a slanting angle using a knife or harvester.
- Bunch the heads together and carry them to a spread polythene sheet
- Harvest at right time
 - A delay in harvesting leads to sprouting especially if there are high temperatures and moisture.
- The panicle is cut from the standing stalk at about 16-20 percentage moisture content.
- Dew should be avoided during harvesting as it leads to sprouting.
- Late harvesting should be avoided as it can lead to grain deterioration and losses due to shedding of the grain from the panicles

b) Transportation

Transport harvested millet and sorghum in containers which do not permit spillage. These include sacks, cut jerrycans, buckets among others

c) Threshing

Most farmers use sticks to thresh millet and sorghum
Thresh on a lined surface or in sealed sacks to avoid spillage
Use moderate force when threshing to avoid damage to grains

d) **Cleaning**

- Grain can be cleaned by winnowing. Washing in water can be used to remove most dust
- Fine screens can also be used to clean millet and sorghum

e) **Drying**

Like maize, millet and sorghum should be dried on lined clean surfaces, protected from rain, dust, insects and animals and dried to at least 13% moisture content

f) **Milling**

Millet and sorghum may be milled using the traditional milling stones but this is laborious. Quick milling can be done using commercial hammer mills.

It is recommended that parts of the mill that get in touch with the grains or flour be made of stainless steel

CASSAVA AND SWEET POTATOES

a) **Harvesting**

Cassava

- Harvesting cassava roots is usually done by hand and is easier when the soil is moist.
- Harvesting is also easier if planting is on ridges or in beds and in loose or sandy soils, rather than on flat ground and in clay or heavy soils
- Harvest cassava roots at the right stage of maturity (usually 9-12 months or 15-18 months for late-maturing varieties) in order to optimize the product yield and output.
- Avoid over-aged or immature cassava roots. Over aged cassava roots tend to be woody and tough that making processing hard whereas the immature roots have a low starch content thus give low product yield after drying and can easily deteriorate.
- Harvesting too early results in low yield and poor eating quality; on the other hand, when the roots are left too long in the soil, the central portion becomes woody and inedible
- Ensure that harvested cassava roots are fresh, firm, clean, wholesome and free from pests and diseases to ascertain high quality of the final product.



Sweet potatoes

- Should be harvested when the majority of roots have reached the desired size for the intended market (3 to 3.5 months from the time of planting)
- Average root size in a field can be estimated by removing the soil around several randomly selected plants

- Sweet potatoes will continue to enlarge if left in the ground, but root diseases and insect damage typically increase with the amount of time the roots remain in the soil.
- The sweet potato vines should be cut off (to toughen skin) at the soil level prior to the intended harvest date.
 - During the dry season, the vines should be removed three to seven days before digging.
 - During the rainy season, the vines should be left intact until just prior to harvest.
- Sweet potato roots can be harvested by hand or by machine.
 - Manual harvesting involves the use of tools such as hoe, spade or forked hoe which loosen the soil and undercut the roots
- Care must be taken to avoid cutting or injury to the roots.
- The roots should be handled gently to avoid skinning and bruising.
 - Bruising and skinning leads to faster shrinkage (weight loss) and inferior appearance of the roots
 - Farmers are therefore advised not to throw or step on the roots.



Bruising due to abrasions

b) Transportation from field

- The cassava and sweet potatoes should be gently placed in strong well ventilated field containers for transport out of the field e.g. Wooden crates or strong plastic containers are much better field containers than sacks or reed baskets (result into excessive skinning).
- Rectangular crates stack better and allow more efficient use of space in a storage house than do sacks or reed baskets
- The transport containers should be lined with an inner liner made from a soft material such as leaves or old clothes to protect the roots from abrasions during handling
- When transporting sweet potatoes, containers should not be overfilled with roots above the upper rim, as stacking will cause injury to the top layer of roots.
- Transport harvested cassava and sweet potatoes to the processing site quickly to prevent onset of deterioration. Carts, wheelbarrows, draught animals or bicycles can be used

- Care has to be taken while transporting cassava and sweet potato roots to minimize damage that exposes the roots to deterioration
- Processing of cassava and sweet potatoes should be as soon as possible if value is to be added, most preferably within 8-12 hours after harvesting to prevent fermentation, bad color and repulsive taste that may develop. This leads to low product recovery and quality.

c) **Handling of fresh cassava and sweet potatoes**

Fresh cassava and sweet potatoes are highly perishable thus storage of fresh roots is hindered by fast deterioration rate. Precautions can be taken to slow the deterioration of the roots. These are described below for cassava and sweet potatoes

Cassava

If the cassava is to be sold fresh as roots and are to be stored for some time, the following should be done:

- Proper curing (skin thickening) immediately after harvest to reduce water loss and to lower the incidence of decay during storage. To cure cassava, pile the tubers in a partially shaded area.
 - Cut grasses or straw can be used as insulating materials and the pile should be covered with canvas, woven grass mats or any other non-conductor lining.
 - Curing requires high temperature and high relative humidity (RH), and this covering will trap self-generated heat and moisture.
 - The stack should be left undisturbed for about four days.
- The shelf life can also be elongated by cleaning and waxing the roots
- Cassava roots should never be washed prior to curing and/or storage, as this will likely result in severe decay.
- Storage of fresh cassava roots
 - Delayed harvesting can preserve cassava roots but this increases risk of rodent, insect and disease attack and decay
 - Roots can be stored in ground buried trenches or holes filled with soil. However, this should not exceed 2 months otherwise the roots become sweeter and less starchy
 - Another method of storing cassava is to place them in wooden crates containing damp sawdust but it should not be too moist as fungal growth can take place. Storage life of about 1 month is achieved
 - Above-ground storage structures should be located in shaded areas free from standing water during heavy rains.

Preparation for market

- The surface of the cassava roots should be cleaned by removing any visible dirt
- The roots should then be sorted to remove diseased and damaged roots
- The roots can be dipped in melted wax to further prolong storage

Sweet potatoes

- Sweet potatoes are highly susceptible to sunburn damage so should be stored away from sunshine
- The damaged areas of the skin remain permanently discolored and are very susceptible to postharvest decay.

- The roots should be gently dry brushed to remove excess soil prior to curing
- Leaving harvested sweet potatoes in the field overnight may cause substantial injury due to cooling
- Improper storage may lead to shrinkage and sprouting, increasing losses. Proper curing prevents this

PROCESSING ROOTS DRIED CHIPS AND FLOUR

a) Peeling

- Take care not to remove useful parts of the roots with the peels.
- While using knives, peeling loss can be reduced by ensuring right size, age and wholesomeness of the tubers as well as carefulness of the people involved in peeling.
- Peeled roots should immediately be dipped in water after peeling while waiting to be washed. This is to prevent root discoloration.
- Remove any woody parts
- Use stainless steel knives to peel roots. Peeling should be done on surfaces which are easy to clean
- Remove the peels and all spoilt portions



b) Washing

- Wash peeled roots thoroughly with clean water to prevent contamination.
- Wash immediately after peeling to prevent change in color and quickened deterioration.
- Remove all dirt, sand, sticky mud, and smelly parts.

c) Chipping

- Chip roots into small, thin and relatively uniform chips immediately after washing to ensure adequate and uniform drying. This could be done using mechanical chippers if accessible or by hand
- During chipping, the product should not be in contact with soil or dirty surfaces to avoid contamination.
- The machinery is used, it should be thoroughly washed before and after chipping
- Surfaces that come in contact with roots during chipping should be made of stainless steel.



Manual chipper

d) Grating- **Done if production of flour is intended, if grating is done, chipping is skipped**

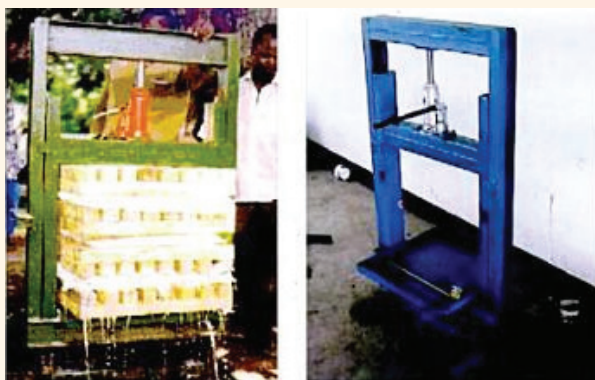
- Wash the grater thoroughly before and after grating to prevent contaminating the products
- For all processing machines, surfaces that come in contact with roots should be made of stainless steel.
- During grating, the product should not be in contact with soil or dirty surfaces
- Grate the roots immediately after washing to maintain the original root color and improve microbial quality of the roots.
- Collect the grated mash in clean containers such as basins.
- Pack the mash into clean polypropylene sacks with a fine mesh and tightly fasten them for dewatering.
- The grating area should be well drained.
- Do not allow the sack containing the mash to touch dirty surfaces such as floors



Motorized grater

e) **Pressing/Dewatering- Done following grating**

- The grate/mash has to be packed in clean bags
- The press should be cleaned before and after use to avoid contamination. Dewatering process may take 20 minutes to 2 hours depending on the type of press used.
- The surface of the press in contact with the product should be made in stainless steel
- Water from the mash should drain easily to keep the place clean
- Allow the mash to get well dewatered to form a cake that crumbles easily.
- The dewatering should be done as quickly as possible to prevent the mash from fermenting
- The de-watered mash should be placed on clean materials like polypropylene sheets



Press

f) **Drying**

- Chips and mash/cake should be dried on waterproof black polyethylene sheet to hasten the drying process, because it absorbs heat.
- Clean the drying surface thoroughly before spreading the mash or chips for drying
- Drying should be done preferably on raised platforms to minimize contamination by dust, rodents and insects.
- The product should be spread thinly (about 2 cm thick) to hasten the drying process.
- Drying the mash may take 2 to 3 hours while chips may take 3 to 5 hours depending on the weather.
- For safe storage and processing, the mash and chips should be dried to 12% moisture content- this is ascertained by using a moisture meter or other traditional methods e.g. biting
- Preferably, the dried mash or chips should be milled immediately to minimize contamination
- Spread granules or chips regularly for fast drying.
- Avoid interrupted or delayed drying. Cassava and sweet potatoes dried over an extended period results in low recovery and poor quality of flour and chips.
- Pack dry granules or chips into clean moisture-proof containers or sacks after cooling.

- If not milled immediately, chips should be collected and stored in clean air tight bags to prevent moisture re-absorption, growth of molds and insects.



Drying platform

g) Milling

- Leave the flour to cool just after milling.
- Sieve if necessary.
- Put the flour in a clean moisture-proof container.
- The surfaces of a milling machine in contact with the product should be made from stainless steel
- Preferably, a mill should be dedicated to processing cassava or sweet potatoes only. In event that, a multipurpose mill is used, it is important to pass at least 5 kg of the product to clean the system before milling the whole batch.

h) Packaging

- Use food grade clean bags to prevent contamination by microorganisms and spoilage.
- Check packaging materials for packaging integrity markers, including leakage and dust.
- Weigh and pack the flour in bags of appropriate sizes.
- The dried product should be packaged in clean plastic bags with inside lining to avoid absorbing moisture. The bag should be sealed or stitched as appropriate.
- Properly label the packages. The following information should be included if available:
 - Common name/brand name
 - Name of manufacturer
 - Batch/code No
 - Net mass
 - Manufacture and expiry dates
 - Storage information

- Sew or seal the top securely and adequately to prevent spillages and contamination.



*Packaged
Cassava flour*

i) Storage

- Store packed products in a cool and dry place
- Sacks should be stacked on pallets and off the walls (about 1 m away)
- Bags should be removed from the store according to the principle of first in first out. This prevents losses due to quality deterioration in store.
- Hermetic storage is the best storage for chips or slices to prevent insect damage and moisture pick up e.g. use of triple bags
- Keep stores clean and free of vermin and insects. This could further be enhanced by regular fumigation.
- Inspect unit packages during storage or just before storage. This prevents moisture pick up, spillages, insect or pest attack of the products during storage.

