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Training Manual for the Production of Cassava Products in Liberia




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Cover photos: a cassava demonstration plot, dry hammer mill, gari roaster and yellow-fleshed cassava roots at IITA. Photos by IITA.

Contents

Introduction

Cassava is the second staple food crop most consumed in Liberia after rice. It can grow and do well in almost all counties in the country and is produced by over 60% of farming households. Apart from providing food for the teeming population, cassava is an important contributor to the gross domestic product (GDP). There is a need to strengthen and increase the domestic production systems to achieve food security, improve the standard of living of subsistence farmers, and contribute to the country's GDP.

Cassava is a perishable commodity with a shelf life of less than threedays after harvest. Processing provides a means of producing shelf stable products;thereby reducing losses, adding value at a local rural level, and reducing the bulk to be marketed (Phillips et al. 2004). As urban population expands, the demand for more convenience and shelf-stable foods increases. Some cassava foods, such as gari, tapioca, and attieke, are highly prized by urban populations, and these have managed to retain their markets. Imported food products are important urban foods but there is still a high demand for traditional foods, although they are often considered less acceptable because of quality and safety concerns (Sanni et al. 2007).

In Africa, cassava is currently utilized for two main purposes: human food and industrial use. Estimates for the percentage of cassava used for industrial utilization range from 5 to 16% while the remaining isdirectly used for human consumption. Most of cassava's industrial utilization is for animal feed. About 10% of its industrial demand consists of high quality

cassava flour used in biscuits and other confectioneries, dextrin, pre-gelled starch for adhesives, and starch for pharmaceuticals and seasonings.Failure to adequately develop postharvest and marketing systems for cassava has, for many years, limited the contribution of the crop in economic growth and poverty reduction.

In spite of the extensive research activities on cassava, there seems to be wide variation with no control in the processing of cassava within and among the countries of the sub-region. There is therefore the need to have a document containing standardized procedures in cassava processing operationstoempower processors and other stakeholders for product quality and a competitive market. Therefore, this training manual focus on the production of HQCF, starch, gari, and fufu powder, as well as the standard operating procedures (SOPs) in the cassava processing factory, and also serves as part of the International Institute of Tropical Agriculture (IITA) contribution to the development of the cassava sector in Liberia, through its collaboration with the Liberia Ministry of Agriculture in the implementation of the Smallholder Agricultural Productivity Enhancement & Commercialization (SAPEC) Project.

Production of High Quality Cassava Flour 2

Background information

High quality cassava flour (HQCF) is unfermented, smooth, odorless, white or creamy and fine flour produced from wholesome freshly harvested cassava (10–12 months after planting) roots. As a result of increase in the price of wheat in the international market and unfavorable exchange rates in West Africa, HQCF was introduced and is now gradually gaining popularity in sub-Saharan Africa (SSA).HQCF has contributed appreciably to cassava industrial revolution especially in Nigeria and Ghana (Sanni et al. 2009), with enormous potentials in the other countries within the sub-region. The product has been found to be suitable for making a variety of pastries, whole or in the composite form (cakes, cookies, doughnuts, and bread), and convenience foods. It is also an acceptable raw material for the manufacture of industrial items such as textiles, plywood, and paper (Dziedzoave et al. 2006). The processing of cassava roots into HQCF as a primary industrial raw material has the potential to jump-start rural industrialization, increase market value of cassava root,and improve famers' earnings and their livelihoods.

Governments of some cassava-growing nations are making efforts to promote competitive production and processing of cassava into industrial raw materials for import substitution and foreign exchange earnings. To achieve this, policies and laws are being put in place to promote market diversification and expanded utilization of HQCF, and the Republic of Liberia should not be left out.

Training objective

The objective of this training is to empower trainees to produce HQCF for domestic and commercial use.

Training needs

Materials

a. Fresh cassava roots (10–12 months).
b. Basins for washing and packing washed roots.
c. Clean washing water.
d. Clean stainless steel knives for peeling.
e. Packaging materials for finished product.
f. Clean cloth or used sacks for washing.
g. Clean polyethylene sacks for dewatering.
h. Black polyethylene sheet for sun-drying.

Equipment

i. Slicer/Chipper.
j. Cassava grater.
k. Cassava press.
l. Dryer (flash, cabinet, or rotary).
m. Milling machine/hammer mill.
n. Sealing and stitching machines.
o. Weighing scale.
p. Mechanical sifter.
q. Elevated platform for solar drying.

Unit operation recommended for HQCF production

Harvesting fresh cassava

- Where sun or solar drying is used, avoid harvesting or processing of cassava to HQCF at periods when it is likely to rain or the atmosphere is extremely humid. If mechanical dryers such as flash, cabinet, or rotary dryers are use, HQCF can be processed anytime.
- Ensure the variety to be harvested is good for HQCF production. Select well matured (9–12 months) cassava roots by testing for maturity or through information from the source, seller, or planting records. Avoid over-aged and diseased roots as they could be woody or rotten inside. Woody or rotten roots (e.g., brown streaked roots) have low starch and/or dry matter contents and adversely affect quality (microbial, functional, and aesthetic) and yield of HQCF.
- Harvest by uprooting roots in a manner that minimizes bruises or breakages to prevent rapid deterioration (loss of starch through microbial and enzymatic activities, and discoloration through vascular streaking) of the roots, which could affect quality of HQCF.
- Transport harvested cassava quickly to the processing site and processed (within 24 h after harvest) to avoid deterioration. If processing is likely to be delayed by a few hours (a condition that should be avoided), leave short stalks on the roots during harvest and keep unpeeled roots under cool shade or covered. Do not leave roots in the sun.

Peeling

- Remove woody stalks on the roots. Use wide and broad-bladed stainless-steel knives for peeling. There are variations in the method of manual peeling (longitudinally and transversely) depending on the variety, root size, season of the year, and traditional practice. Mechanical peelers could also be used. Whatever method is used for peeling, there should be no peel fragment after the peeling process.
- Transfer peeled cassava roots into stainless steel washing tank, drums, or pans and immerse peeled roots under water for immediate washing. Do not expose peeled roots to the air as this may cause discoloration after prolonged exposure neither should you leave the peeled roots in water for too long as this may result in fermentation.

Washing

- Use potable water from a credible source or treat water from a questionable source before use. Wash roots thoroughly by hand rubbing the roots in water or by vigorous agitation and stirring. Rewash peeled roots in successions of clean water until complete absence of dirt, sand, sticky mud, fecal matter, or offensive odor.
- Inspect washed roots for any rotten or colored portion and remove.
- Drain off all waste wash water from cassava roots after washing before further processing.

Chipping

- Chip/slice the cassava root with either a stainless-steel knife or chipping machine. The chipping/slicing should be done thinly to reduce the drying time.

- Chipping/slicing is done when either sun drying or a cabinet dryer will be used for the drying process.
- Disperse sun-dried chipped/sliced cassava roots properly in order to reduce deterioration and hasten the drying process.
- Package the dried chips properly and place on a wooden platform to reduce moisture uptake before milling into HQCF.
- Ensure that the moisture content of the dried chips for storage is not higher than 12%

Grating

- Grate cassava immediately after washing using a clean, mechanized stainless steel cassava grater Avoid manual grating with an improvised local grater.
- Place clean containers at the outlet chute of the grater to receive and hold grated cassava mash during grating.
- Start the grater, allow it to achieve operating speed before pouring clean cassava roots into the hopper and operate the grater to grate the cassava roots into mash. Do not put the cassava root into the grater before it is switched on or immediately it is switched on.
- Wash cassava grater thoroughly with clean water before and after grating.

Dewatering by mechanical press

- The grated cassava mash should be packed into clean polyethylene/polypropylene tiny woven sacks for dewatering. Sacks of cassava mash should never be placed on bare floor or on any dirty surface. They should be placed on specially prepared wooden platforms off the

ground or in tiled troughs provided with a drain. Workers should first wash their hands or wear gloves before packing the cassava mash into sacks for dewatering.

- Dewatering should be done using a mechanical press and not wood or stones. Many designs of mechanical dewatering machines are available: single or double screw presses, sometimes combined with hydraulic system, are mostly used for de-watering cassava at the small-scale level.
- Turn the screw of the cassava press anti-clockwise with the aid of the horizontal press bar to raise the press plate to a suitable height. Place the bagged cassava mash (30–40 kg) flat on the cassava press platform. Fold the mouth of the bag on top or under and or simply tie the bag. Two to five bags of cassava mash may be loaded at once depending on the capacity of the press (i.e., height, maximum pressure of the hydraulic system) and the physical strength of the operator in case of the screw/ combined screw-hydraulic press. Wooden racks may be placed in between sacks to improve dewatering efficiency.
- Apply pressure by clockwise screwing of the plate onto the bags until the maximum pressure level is attained and the bags are hard. Load pressure reduces as liquor drains out of the bags and the bags become softer when tested with finger.
- Repeat the clockwise turning of the screw press bar lever or operate the hydraulic press regularly to maintain load pressure until the mash is well dewatered. That is when water stops coming out of the bags.
- Remove dewatered cassava press cake (check by finger-feel for the hardness of press cake as an indication of a well dewatered press cake before removal). The moisture

content of well dewatered cassava cake ranges between 40 and 45%; often attained after 40 minutes depending on the press capacity.

- Empty cassava cake into clean pans or bowls for granulation.

Cake breaking/granulation

- Pressed-cake should be granulated using a granulating machine (cassava grater might be used). This improves the uniformity of drying.
- Use clean containers to hold the granulated mash. The granulated mash should be dried immediately and not kept for a long time to reduce contamination.

Drying

- The Flash dryer is very important for drying. Many designs of flash dryers are commercially available internationally, in Brazil, Ghana, Nigeria, among other countries. Flash dryers dry at an operating temperature of 100–250 ^{o}C or more. At such high temperatures, the hot-air-product contact time to achieve complete drying without destroying the functionality of the granules could be as short as seven seconds. The drying capacity of a flash dryer depends on many factors but could be as high as 10 t/hour.
- Pack dry grits after cooling into clean containers or sacks for milling into flour.

Milling/Sifting

- Pour dried cassava grits into the hopper of the mill.
- Place a receptacle at the outlet of the machine to receive the milled flour.

- Start the motor/engine and manually feed the milling chamber with product from the hopper. Stop the machine after milling.
- You can use a hammer mill with a sieve of appropriate aperture size to produce HQCF of the required particle size (250–500 µ). Sifting of flour will be necessary if a plate or attrition mill is used.
- Sift the flour with a sifter. Avoid overloading the sifter.
- Receive the sifted flour with a clean container and stop the machine when sifting is complete.

Packaging/labeling

- Pack HQCF in suitable, clean, insect-free, light and moisture proof packaging materials that safeguard the hygienic, nutritional, physical, and organoleptic qualities of the product. The packaging material should not impart any toxic substance or undesirable odor or flavor to the product.
- Pack HQCF in polypropylene sacks (25–50 kg) lined with thin polyethylene bags for bulk sales, or in smaller bags (paper, polythene) as unit packages for the retail market. Arrange the unit packages (small bags) into secondary packages of cardboard boxes before retail.
- Label each packaging material by providing the following information:

— The common name and/or brand name.

— Name of the manufacturer or packer.

— Batch or code number.

— Net mass in metric units.

— Date of manufacture.

— Country of origin.

— Expiry date.

— Regulatory body registration number.

— List of raw materials used.

— Nutritional composition of product.

— Inscribe the following on the package: ‘Store in cool dry place’.

Storage/marketing

- Use clean vehicles to transport packaged HQCF for distribution or storage.
- Store HQCF in bulk on pallets in well-ventilated storage warehouses, free from pest.
- Keep packaged products intended for retail on shelves during storage.

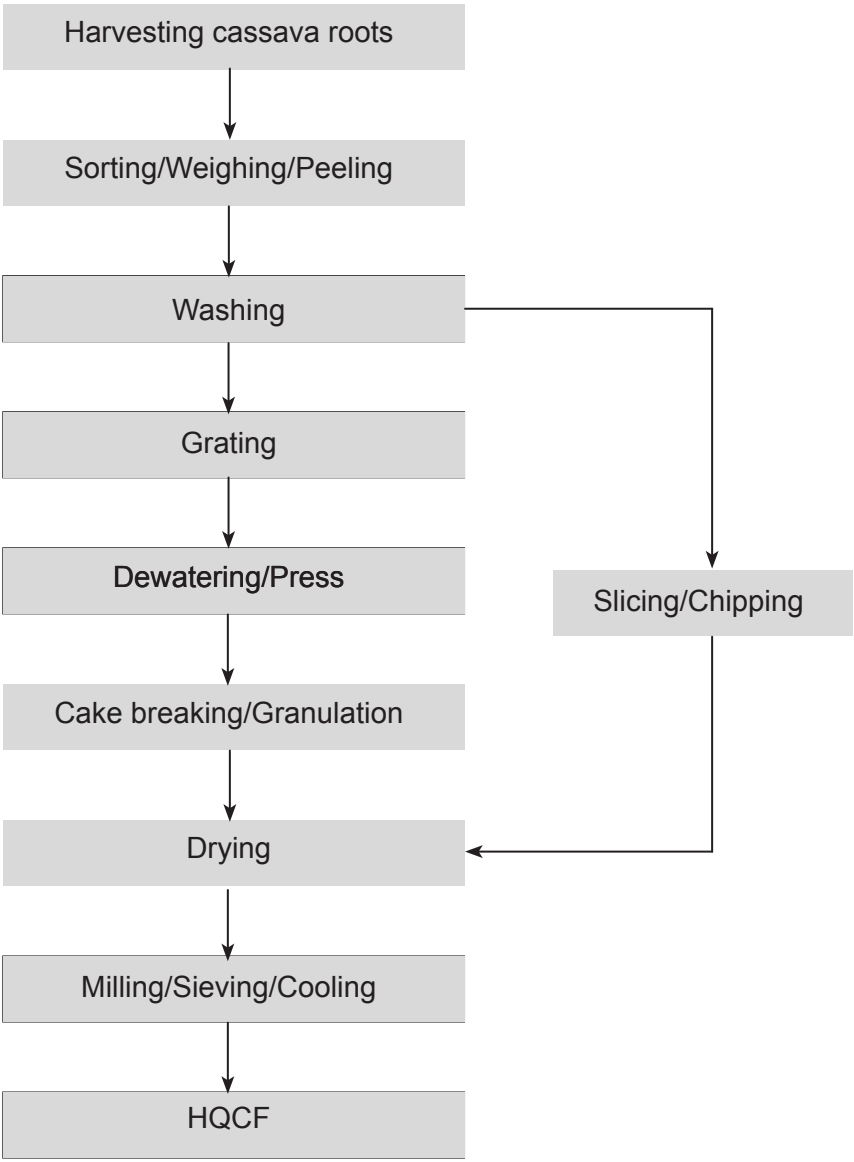

Figure 1. Flow chart of HQCF production.

Production of Starch 3

Background information

Starch is fine flour produced from wholesome freshly harvested cassava root. Starch is one of the most abundant substances in nature, a renewable and almost unlimited resource. Starch is produced from grain or root crops. It is mainly used as food, but is also readily converted chemically, physically, and biologically into many useful products. Starch processed from cassava root (cassava starch) is an important domestic and industrial raw material used in the manufacture of various products including food, adhesive, thickening agents, paper, and pharmaceuticals. It has many remarkable characteristics including high paste viscosity, high paste clarity, and high freeze-thaw stability, which are advantageous to many industries. These characteristics of cassava starch have made it progress from domestic uses to highly specialized industrial uses. Recent dwindling in oil revenue and difficulties in getting foreign exchange for corn starch has made users of corn starch to look to cassava starch as a substitute. However, the quality of the starch must be acceptable for the end-users. The taste and odor of starch should be characteristic of the product. It should be white or cream in color, odorless, bland or sweet in taste, and free from adulterants, insect infestation, sand, peel fragments, dust, and any other impurities.

Training objective

The objective of this training is to empower trainees to produce both food grade and non-food grade starch for domestic and commercial use.

Training needs

Materials

- Fresh cassava roots (10–12 months).
- Basins for washing and packing washed roots.
- Clean washing water.
- Clean stainless-steel knives for peeling.
- Packaging materials for finished product.
- Clean cloth or used sacks for washing.
- Clean polyethylene sacks for dewatering.
- Black polyethylene sheet for sun-drying.

Equipment

- Cassava grater.
- Cassava press.
- Dryer (Flash, cabinet, or rotary).
- Milling machine/hammer mill.
- Sealing and stitching machines.
- Weighing scale.
- Mechanical sifter.
- Elevated platform for solar drying.

Unit operations recommended for Starch production

Harvesting fresh cassava

- Where sun or solar drying is used, avoid harvesting or processing of cassava to starch at periods when it is likely to rain or the atmosphere is extremely humid. Starch can be processed at any time using mechanical dryers.
- Ensure the variety to be harvested is good for starch production. Select well matured (9–12 months) cassava roots by testing for maturity or through information from the source, seller, or planting records. Avoid over-aged and diseased roots as they could be woody or rotten inside. Woody or rotten roots (e.g., brown streaked roots) have low starch and/or dry matter content which adversely affect quality (microbial, functional, and aesthetic) and yield of starch.
- Harvest the roots by uprooting them in a manner that minimizes bruises or breakages in order to prevent rapid deterioration (loss of starch through microbial and enzymatic activities, and discoloration through vascular streaking) of the roots, which could affect the quality of the starch.
- The harvested cassava root should be transported quickly to the processing site and processed (within 24 h after harvest) to avoid deterioration. If processing is likely to be delayed by a few hours (a condition that should be avoided), leave short stalks on the roots during harvest and keep unpeeled roots under a cool shade or covered. Do not leave the roots in the sun.

Peeling

- Remove the woody stalks on the roots. Use wide and broad-bladed stainless-steel knives/peelers for peeling. There are variations in the method of manual peeling (longitudinally and transversely) depending on the variety, root size, season of the year, and traditional practice. Mechanical peelers could also be used. Whatever method is used, there should be no peel fragments after the peeling process.
- Transfer the peeled cassava roots into the washing tank, drums, or pans and immerse the peeled roots under water for immediate washing. Do not expose the peeled roots to the air as this may cause discoloration after prolonged exposure, which could affect product quality.

Washing

- Use potable water from a credible source or treat water from a questionable source before use. Wash the roots thoroughly by hand rubbing the roots in the washing water or by vigorous agitation and stirring. Rewash the peeled roots in successions of clean water until there is a complete absence of dirt, sand, sticky mud, fecal matter, or offensive odor.
- Inspect the washed roots for any rotten or colored portion and remove before grating.
- Drain off all waste wash water from the cassava roots after washing.

Grating

- Grate the cassava root immediately after washing using a clean mechanized stainless-steel cassava grater.
- Place clean containers at the outlet chute of the grater to receive and hold the grated cassava mash/pulp during and after grating.

- Start the petrol/diesel engine or electric motor of the grater, allow it to achieve operating speed before pouring clean cassava roots into the hopper and operate the grater to grate the cassava roots into a mash.
- Wash the cassava grater thoroughly with clean water after and before grating.

Homogenization

- This process involves the mixing of water with grated cassava mash in an agitated container/drum. Water is run continuously into the homogenizer while the mixed content is pumped into the extractor.
- The extractor could be a screen separator or a sieving machine.
- In the absence of a homogenizer, the grated cassava mash could be mixed properly with clean water using the hands before wet sieving or starch extraction.

Extraction

- This is the process of separating the starch granules from fibrous and other extraneous materials. The separation of starch is achieved using a vibro-sieve, screen separator, or muslin cloth.
- In separating starch granules from cellulose fiber, the mash is mixed with an appreciable amount of water during screening.
- For total separation this mixing is on a continuous basis until the end of the extraction process.

Sedimentation

- The term sedimentation as used here includes the series of operations for separating the pure starch from the water mixture after extraction.

- The quantity of starch produced depends to a great extent on proper performance of this operation. This operation can be done in tanks or a settling floor table. A settling table is a shallow concrete channel of about 30 cm deep of various lengths and widths depending on factory capacity.
- The table is slightly inclined (1 cm/m) for free flow along the table. The inner part of the table is covered with tiles. Holes with stoppers are fitted into the walls of the table.
- During the sedimentation process, the table filled with starch milk is allowed to settle overnight (about 20 h for complete settling) after which the water and other contaminants are discarded. The settling must not be allowed to overstay (to prevent fermentation).

Dewatering

- Many designs of mechanical dewatering machines are available. They include single or double screw presses, sometimes combined with a hydraulic system, and are mostly used for dewatering cassava at the small-scale level.
- Turn the screw of the cassava press anti-clockwise with the aid of the horizontal press bar to raise the press plate to a suitable height. Place the polypropylene bag of wet starch (30–40 kg) flat on the cassava press platform. Fold the mouth of the bag on top or under or simply tie the bag. Two to five bags of wet starch may be loaded at once depending on the capacity of the press (i.e., height, maximum pressure of the hydraulic system) and the physical strength of the operator in case of the screw/combined screw-hydraulic press. Wooden racks may be placed in between bags to improve dewatering efficiency.

- Apply pressure by clockwise screwing of the plate onto the bags until the maximum pressure level is attained and the bags are hard. Load pressure reduces as liquor drains out of the bags and the bags become softer when tested with a finger.
- Repeat the clockwise turning of the lever of the screw press bar or operate the hydraulic press regularly to maintain the load pressure until wet starch is well dewatered.
- Remove the dewatered starch cake (check by finger-feel for the hardness of press cake as an indication of a well dewatered cake before removal). The moisture content of well dewatered starch cake ranges between 35 and 40%; often attained after 10–40 minutes.
- Empty the cake into clean pans or bowls for granulation.

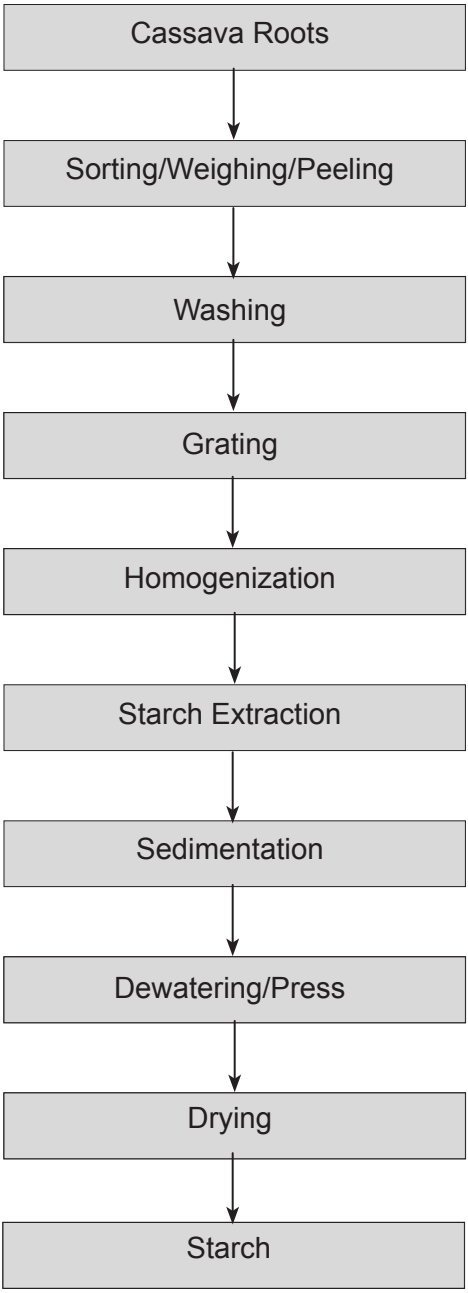

Figure 2. Flow chart for production of starch

Cake breaking/granulation

- The cake should be granulated using a mechanical grater or granulator. This improves drying uniformity.
- Use clean containers to hold the granulated semi dried starch before proper drying.

Drying

- Flash, cabinet, or rotary dryers are used for drying starch. Many designs of flash dryers are commercially available internationally, in Brazil, Ghana, Nigeria, for example. Flash dryers dry at an operating temperature of 100–250 ^{o}C. At such high temperatures, the hot-air-product contact time to achieve complete drying without destroying the functionality of the granules could be as short as seven seconds. The drying capacity of flash dryers depends on many factors but could be as high as10 t/hour.
- Package dry starch after cooling into clean containers or sacks.
- Packaging/labeling and storage/marketing of starch are similar to that of HQCF.

Note: The production of fufu powder is similar to that of starch except that submerged fermentation of the cassava root is done after peeling without grating.

Production of Gari 4

Background information

Gari is a partially gelatinized or toasted cassava product with a slightly fermented flavor and sour taste. In West Africa, it is the most consumed and traded of all food products made from cassava roots. It is consumed either soaked in cold water or stirred in boiling water to make a stiff paste known as “eba” and consumed with preferred soup. Gari can be yellow (if produced from yellow-fleshed cassava root or fortified with red palm oil) or white. The wide consumption of gari is attributed to its relatively long shelf life and its easy preparation as a meal. However, there are variations in the gari produced within the subregion in terms of physical, chemical, and sensory qualities.

Training objective

The objective of this training is to empower trainees to produce high quality and safe gari for domestic and commercial use

Training needs

Materials

- Fresh cassava roots (10–12months).
- Basins for washing and packing washed roots.
- Clean washing water.
- Clean stainless-steel knives for peeling.
- Packaging materials for finished product.

- Clean cloth or used sacks for washing.
- Clean polyethylene sacks for dewatering.
- Sieve/sifter.
- Fuel for toasting/roasting/garifying; (fire wood, charcoal, or cooking gas).
- Packaging materials for finished product.

Equipment

- Cassava grater.
- Cassava press.
- Cassava grater.
- Gari toaster/roaster/garifier.
- Mechanical sifter (for medium to large-scale processing).
- Fermenting trough.
- Sealing and stitching machines.
- Weighing scale.

Unit operations recommended for Gari production

Harvesting fresh cassava

- Where the sun or solar drying is used, avoid harvesting or processing of cassava to starch at periods when it is likely to rain or the atmosphere is extremely humid. Starch can be processed at any time if mechanical dryers are used.
- Ensure that the variety to be harvested is good for starch production. Select well matured (9–12 months) cassava roots by testing for maturity or through information from the source, seller, or planting records. Avoid over-aged and diseased roots as they could be woody or rotten

inside. Woody or rotten roots (e.g., brown streaked roots) have low starch and/or dry matter content and adversely affect the quality (microbial, functional, and aesthetic) and yield of starch.

- Harvest the roots by uprooting in a manner that minimizes bruises or breakages to prevent rapid deterioration (loss of starch through microbial and enzymatic activities, and discoloration through vascular streaking) of the roots, which could affect the quality of the starch.
- Harvested cassava root should be transported quickly to the processing site and processed (within 24 h after harvest) to avoid deterioration. If processing is likely to be delayed by a few hours (a condition that should be avoided), leave short stalks on the roots during harvesting and keep unpeeled roots under the cool shade or covered. Do not leave roots in the sun.

Peeling

- Remove woody stalks on the roots. Use wide and broad-bladed stainless steel knife/peeler for peeling. The method of manual peeling can vary (longitudinally and transversely) depending on the variety, root size, season of the year, and traditional practice. Mechanical peelers can also be used. Whatever method is used, there should be no peel fragments after the peeling process.
- Transfer the peeled cassava roots into a washing tank, drums, or pans and immerse peeled roots under water for immediate washing. Do not expose peeled roots to the air as this may cause discoloration after prolonged exposure, which could affect product quality.

Washing

- Use potable water from a credible source or treat water from a questionable source before use. Wash roots thoroughly by hand rubbing the roots in washing water or by vigorous agitation and stirring. Rewash peeled roots in successions of clean water until there is a complete absence of dirt, sand, sticky mud, fecal matter, or offensive odor.
- Inspect washed roots for any rotten or colored portion and remove such before grating.
- Drain off all waste wash water from cassava roots after washing.

Grating

- Grate cassava root immediately after washing using a clean mechanized stainless-steel cassava grater.
- Place clean containers at the outlet chute of the grater to receive and hold grated cassava mash/pulp during and after grating.
- Start petrol/diesel engine or electric motor of the grater, allow it to achieve operating speed before pouring clean cassava roots into the hopper, and operate the grater to grate the cassava roots into mash.
- Wash cassava grater thoroughly with clean water after and before grating.

Fermenting

- Put grated cassava mash into a clean polyethylene sack and tie. Allow to stand in a fermenting trough for 2–4 days.
- Arrange sacks in such a way that there is no contact with sand or dirt that can contaminate the mash. Allow free sipping of water from the sacks.

- There are variations in the fermentation period within and among countries. However, fermentation should not be less than two days (to allow development of the characteristic sour taste of gari). Fermentation of less than two days is discouraged.

Dewatering

- Many designs of mechanical dewatering machines are available. Single or double screw presses, sometimes combined with a hydraulic system, are mostly used for dewatering cassava at the small-scale level.
- Turn the screw of the cassava press anti-clockwise with the aid of the horizontal press bar to raise the press plate to a suitable height. Place the polypropylene bag of wet mash (30–40 kg) flat on the cassava press platform. Fold the mouth of the bag on top or under or simply tie the bag. Two to five bags of cassava mash may be loaded at once depending on the capacity of the press (i.e., height, maximum pressure of the hydraulic system) and the physical strength of the operator in case of the screw/combined screw-hydraulic press. Wooden racks may be placed in between bags to improve dewatering efficiency.
- Apply pressure by clockwise screwing of the plate onto the bags until the maximum pressure level is attained and the bags are hard. Load pressure reduces as liquor drains out of the bags and the bags become softer when tested with a finger.
- Repeat the clockwise turning of the screw press bar of the lever or operate the hydraulic press regularly to maintain the load pressure until the wet starch is well dewatered.
- Remove dewatered cake (check by finger-feel for the hardness of press cake as an indication of a well

dewatered cake before removal). The moisture content of well dewatered starch cake ranges between 40 and 45%; often attained after 10–40 minutes.

- Empty the cake into clean pans or bowls for granulation.
- If dewatering is not complete, there will be lumps during toasting which reduces the quality and yield of gari.
- Do not use sacks for too long to prevent bursting during pressing. In some cases of light sacks or over-use of sacks, it is advisable to double the sacks.
- Keep the press and the pressing area very clean with a good drainage system for safe disposal of the effluent to avoid environmental pollution and public health hazards.

Cake breaking/granulation

- Break the cake using clean hands followed by sifting with non-rusting sifter into a clean basin. Sifters made of stainless steel material are preferable.
- Use clean containers to hold the granulated semi-dried grits before proper drying.

Roasting/toasting

- Toast and stir constantly in a large, shallow stainless-steel pan over fire, with a piece of gourd or a wooden paddle until the gari is dried through hand feel. This may take 20–30 min depending on the heat source and quantity of sifted cake.
- The finished product (gari) is usually recognized from the color change from white to cream (for non-palm oil fortified gari or yellow fleshed cassava gari) and crispy hand feel of the grains/particles.

- Toasting can also be done mechanically using an automated garifier or other improved garifier made of stainless steel material and with firewood or charcoal as the heat source.

Cooling

- Collect the toasted gari into a clean basin and spread on a raised platform lined with clean polyethylene material or a white cloth to cool to room temperature.
- Packaging/labeling and storage/marketing of gari are like that of HQCF.

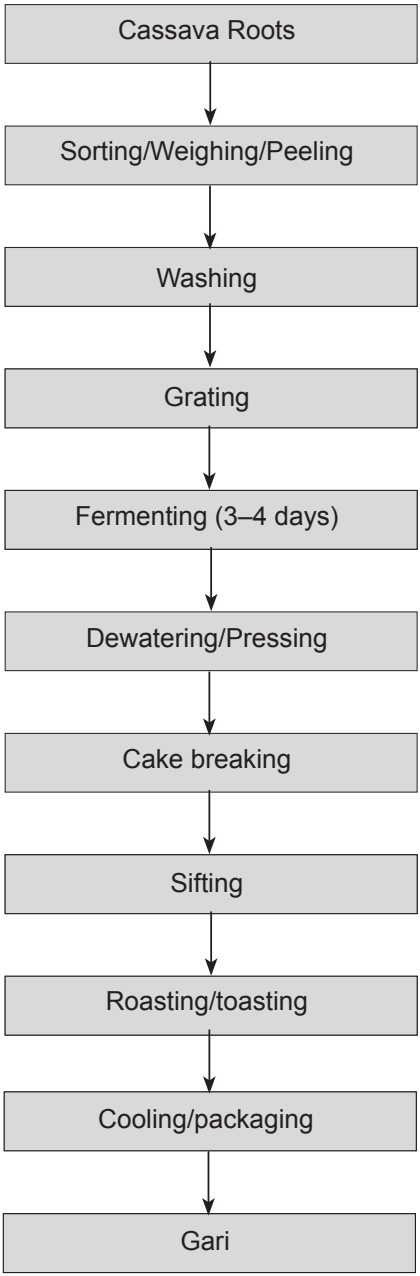

Figure 3. Flow chart of gari production.

Cleaning

The following SOPs should be strictly adhered to in the cleaning of equipment, machines, and processing points in the cassava processing factory:

- The processing environment (peeling and dry section) should be properly swept and kept tidy before and after each production operation.
- The knives, plastic containers, and processing bags should be washed with clean water-odorless liquid soap mixture and allowed to drain before and after use.
- The wash basin should be kept tidy by washing with clean water-odorless liquid soap mixture and allowed to drain before and after use.
- Machines in the wet section should be cleaned by flushing all the corners and inside with water using a hose connected to a water tap.
- The muslin clothes used for wet fufu sieving should be washed with clean water-odorless liquid soap mixture and allowed to drain before and after use.
- The cassava fermenting drums should be washed with clean water-odorless liquid soap mixture and allowed to drain before and after use.
- Machines in the dry section should be kept clean and tidy by dusting using dry dusters before and after each processing operation.
- The packaging section should be kept clean and tidy by sweeping before and after each processing operation.

- Products should be properly arranged on a raised wooden platform in the store to enhance easy cleaning.
- Machines in the packaging section should be properly cleaned by dusting with clean clothes/rags. The moving parts of these machine should be lubricated with specified lubricating oil as at when due.
- All machines and equipment on the processing floor should be properly arranged to enhance efficient cleaning operations.
- The pressers and pressing area should be kept clean with a good drainage system for safe disposal of effluent to avoid environmental pollution and public health hazards.
- Different sizes of micron filters should be placed between the pipe from the water source and that of the processing factory. This water filtration setup should be properly washed with chlorine-clean water mixture every week to avoid inflow of dirt and contamination of water for production.

Machine maintenance

- Wash wet processing machines or equipment with water and odorless detergent and later sterilize with sanitized sterilant such as a chlorine solution (bleach) at the end of every day's operation.
- Clean and dry other machine/equipment at the end of every day's operation.
- Wash and mop the factory floor before and at the end of every day's operation.
- Scrub hands thoroughly before starting work and regularly throughout the day's operation.
- Always use overalls, factory boots, and other factory protective wear (like nose, mouth, and ear covers).

- Lubricate machine moving parts regularly before and after use.
- Do not use necktie, chains, and rings when working in the factory.
- Buttons of factory wears should not be loose when operating machines.
- Place a protective covering on rotating pulley.
- Place fire extinguishers and first-aid-boxes in strategic points in the processing factory.
- Machines should only be operated by qualified personnel.
- Teach all machine operators how to troubleshoot machines.
- Switch off all machines from the main supply after processing.
- Never use bare hands on the grater while in operation.

Water treatment

- The following SOPs should be strictly adhered to in the treatment of water used for processing:
- Connect micron filters of 5, 1, and 0.5 microns in series from the water source to the processing factory.
- Water should flow through the pipe (flowing through 5-micron size filter) from the water source via three different size micron filters of another 5, 1 and 0.5 microns, respectively, connected to the pipe in series. This should be done to ensure the removal of dirt and other extraneous particles from the water before use.
- Water should be made to flow from the last filter (0.5 micron) via the pipe through ultra-violet light connected

between the last filter and the flow of water out of the tap for use. This is to ensure sterilization of the water from the water source.

- Use the filtered and sterilized water for processing operations.
- Wash the micron filters every week with chlorine-clean water mixture to avoid inflow of dirt and contamination.
- Wash the storage tank properly every week with chlorine-clean water mixture to ensure clean water supply into the factory for production.

Quality control of products

- Process only cassava roots without bruise, cut, decayed part, or insect infestation.
- Use stainless steel knives/peelers and not rusting knives/peelers for the complete removal of cassava peel.
- Ferment for 3□4 days depending on the weather condition using clean water for fufu and solid state for gari. This reduces the cyanide in the cassava root.
- Use clean water for processing. In fufu production, use clean unperforated muslin cloth for the sieving and not plastic baskets to prevent the mixing of other extraneous materials.
- Bag the grated cassava mash with clean dewatering polyethylene sacks and press with a stainless-steel presser.
- Dry at the required temperature depending on the products to prevent burning or discoloration
- Cool the products to room temperature before fortification, packaging, and subsequent storage.

- Fortification of the flour could be done with Vitamin A premix (containing Vitamin A, Thiamin, Riboflavin, Nicotinamide, and Iron) at the ratio of 0.25 g Vitamin A/ kg of product using a stainless-steel cone blender before packaging into air-tight, moisture free polyethylene bags.
- Store products in a cool, dry, well-ventilated, insect and rodent free store, on a raised wooden platform. This will prevent moisture uptake.
- Properly channel all waste water into a covered septic tank to prevent product contamination.

Product Development 6

The following cassava products will be developed and introduced to the processors:

- **Custard powder:** This will be developed using the extracted food grade starch. Other ingredients that will be added are sodium chloride, vanilla flavor, and yellow colorant. All the ingredients will be blended with the starch using a stainless steel blender, after which it will be allowed to cool to room temperature before packaging.
- **Fortified tapioca grits:** This will also be developed from the extracted starch. After the starch extraction and dewatering, the cake will be granulated and toasted as done in gari production. Soybean or sesame seed flour will be used as a fortifier to increase the protein content of the tapioca grits.
- **Cascon (a rice analog):** Different ratios of HQCF/ cassava starch will be blended with corn flour/starch, mixed together with water to form dough, and passed through a hot extruder of tiny die sizes to give the size of a rice grain. This will then be dried, cooled, and packaged.

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Appendices

Appendix1.Recommended chemical properties and metallic contaminant level of some cassavaproducts

		Cassava chips	Cassava flour	Cassava starch	Gari
Chemical properties					
S/ No.	Parameters	Requirement	Requirement	Requirement	Requirement
1	Moisture	10%	10%	12%	7%
2	Ash	3%	1%	1%	2%
3	Crude fiber	3%	2%	0%	2%
4	TTA	1%	1%	1%	1%
5	HCN	10ppm	10ppm	10ppm	20ppm
6	Starch	75%	65-75%	95%	75%
7	pH	5.0–6.9	5.0–6.10	5.0–7.0	3.5–4.8
Metallic contaminant limits					
1	Copper	20ppm	20ppm	4.3ppm	NA
2	Lead	1ppm	1ppm	1ppm	NA
3	Tin	15ppm	15ppm	NA	NA
4	Zinc	50ppm	50ppm	19ppm	NA
5	Iron	22ppm	22ppm	22ppm	NA
6	Mercury	0.1ppm	0.1ppm	NA	NA
7	Arsenic	0.1ppm	0.1ppm	NA	NA
8	Aluminum	NA	NA	26ppm	NA
9	Molybdenum	NA	NA	17ppm	NA
10	Sodium	NA	NA	74ppm	NA
11	Manganese	NA	NA	12ppm	NA

Source: Sanni et al. (2005)

Appendix II.Some Cassava Processing Machines/Equipment

Mechanical peeler

Chipping machine

Grating & chipping machine combined

Presser

Modernized gari roaster

Hammer mill

Flash dryer

Sanni et al. (2006)

Modified solar dryer

Sanni et al. (2006)

Rotary dryer

Sanni et al. (2006)

Packaging machine