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Quality management manual for the production of *gari*

Adebayo B. Abass, Nanam T. Dziedzoave,
Bamidele E. Alenkhe, and Braima D. James

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Unleashing the power of cassava in Africa

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To Headquarters from outside Nigeria:
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Within Nigeria:
PMB 5320, Oyo Road
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ISBN 000-000-00000-0-0

Acknowledgment
This manual is based mainly on the implementation experience and recommendations of the USAID/IITA project "Unleashing the Power of Cassava in Africa in Response to the Food Price Crisis (UPoCA), 2008 to 2010. The project was an inter-institutional partnership including 55 partner organizations and 11 agriculture-related firms in the Democratic Republic of Congo (DRC), Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, and Tanzania.

Immense thanks go to USAID for funding the UPoCA project and to all project staff, collaborators, subcontractors, partner organizations, and individuals who participated and/or assisted in the production of this handbook by providing facilities, information, advice, and services.

Correct citation: Adebayo B. Abass, Nanam T. Dziedzoave, Bamidele E. Alenkhe, and Braima D. James. 2012. Quality management manual for the production of *gari.* IITA, Ibadan, Nigeria.

About IITA

The International Institute of Tropical Agriculture (IITA) is one of 15 non-profit research-for-development organizations of the Consultative Group on International Agricultural Res*earch* (CGIAR). IITA (www.iita.org) works with partners in Africa and beyond to tackle hunger and poverty by reducing producer and consumer risks, enhancing crop quality and productivity, and generating wealth from agriculture. The CGIAR (www.cgiar.org), established in 1971, is a strategic partnership of countries, international and regional organizations, and private foundations supporting the work of an alliance of 15 international centers. In collaboration with national agricultural research systems, civil society and the private sector, the CGIAR fosters sustainable agricultural growth through high-quality science aimed at benefiting the poor through stronger food security, better human nutrition and health, higher incomes, and improved management of natural resources.

About IITA project UPoCA

Late in 2008, IITA with funding from USAID initiated the project "Unleashing the Power of Cassava in Response to Food Price Crisis" (UPoCA) as a 2-year transitional response to an increasingly urgent demand by a wide range of stakeholder groups to expand the role of cassava in food, feed, and industrial applications in DR Congo, Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, and Tanzania. The UPoCA project draws on prior research results to increase on-farm cassava productivity and value adding processing for markets enabling individual farmers and famer -based organizations FBOs to realize the potential of cassava in rural economies.

About this manual

This manual is produced by the UPoCA project to guide cassava processing centers for quality management in *gari* production. The manual will help to promote practical implementation of good manufacturing practices (GMP) and good hygienic practices (GHP) in producing *gari*. The manual increases the understanding of and compliance with a Hazard Analysis Critical Control Points (HACCP) quality management in producing *gari*. The manual guides cassava processors on procedures for obtaining quality certification and registering the management practices used in the production process for *gari*. The manual will also be useful to food science and technology students, researchers, and those involved in food control programs.

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Abbreviations

AOAC	Association of Analytical Chemists
CAC	Codex Alimentarius Commission
CCP	Critical control point
CFU	Colony forming units
CNP	Cyanogenic Potential
FBO	farmer based organization
GHP	good hygienic practice
GMP	good manufacturing practice
GSB	Ghana Standards Board
HACCP	Hazard Analysis Critical Control Point
HCN	hydrocyanic acid
IITA	International Institute of Tropical Agriculture
ISO	International Standards Organization
QACCP	Quality Analysis Critical Control Point
QACCP	Quality Analysis and Critical Control Points
RCP	Recommended International Code of Practice
SLSB	Sierra Leone Standards Bureau
SON	Standards Organization of Nigeria
USAID	United States Agency for International Development

Introduction

Gari is a granular food product produced by grating cassava roots into a mash, fermenting and de-watering the mash into a wet cake, and roasting the wet material into gelatinized particles. *Gari* has a slightly sour taste and it could be white or cream depending on the variety of cassava used and the processing method adopted. The particle size of *gari* may vary from 0.6 to1.1 mm depending on the method of production and the preferences of the targeted consumers.

Gari is the most popular cassava food in many West African countries. Due to its convenience and multiplicity of use, *gari* is gradually gaining a foothold in the international food market. Ghana and Nigeria appear to be the principal producers, consumers, and exporters of *gari*. In Ghana *gari* exports grew by 23.2% annually from 2001–2007. Nearly 75% of cassava produced in Nigeria is processed into *gari*. *Gari* is a relatively recent introduction in East and Southern Africa. In Mozambique, *gari* is traditional to the people of Inhambane Province of Mozambique, where it is known as *rale*. The product is currently promoted in West, Central, East, and Southern Africa largely through the work of international agricultural development organizations (e.g., IITA) and NGOs supported by donor agencies (e.g., USAID, Common Fund for Commodities/CFC) who worked to increase food security in the countries.

The *gari* market is competitive, sellers or buyers cannot unilaterally impose prices on the market. In major *gari* producing areas, *gari* is produced by numerous smallholder units which sell *gari* essentially in village markets. Big markets, which are often fewer, act as an assembly center for *gari* from the numerous surrounding smallholder units. Such assembly markets are generally well attended by traders from far and wide, especially those markets that are well known for the supply of top quality *gari.*

Gari quality can be defined on the basis of its safety and fitness for use by the target consumer. Thus in order to satisfy the taste of the consumers a processor needs to integrate quality into the processing operations in order to build quality into the product. In so doing the processor is able to attract more customers and remain competitive in the market place. Both processors and consumers alike have various indices by which they judge the quality of *gari*. These include taste (acidity or sourness), swelling capacity, color, texture, crispiness, and absence of foreign matter (cleanliness). The product must not be too acidic, but should have a high swelling capacity, and must be of a definite color—either white or cream. Sometimes the uniformity and brightness of the color is considered more important than the color itself. With respect to texture, *gari* with a smooth texture is preferred. *Gari* must be crispy or very crispy and should have no sand particles, black specks, or residual peels in it.

Research to improve traditional cassava processing methods for *gari* production was initiated in Nigeria in the early 1950s. The focus has been on machinery and skills to reduce the drudgery of work, eliminate or reduce the HCN in *gari*, and increase its storage period while retaining its taste and quality under hygienic conditions (Idowu 1990). The cassava transformation in Nigeria that occurred from the 1990s was driven by the availability of the new, high yielding cassava varieties and cassava processing machines, mainly graters, for the production of *gari.* Processing of cassava to *gari* for urban consumption with the aid of mechanical graters changed the status of cassava from a subsistence crop to a cash crop in Nigeria and Ghana (Nweke 2004). Past research to increase scientific knowledge of the chemical process of *gari* production helped in understanding the factors and unit operations responsible for the quality characteristics of *gari* including the factors that influence safety. This knowledge, presented partly in Chapter 2, forms the theoretical basis for developing *gari* Quality Management Systems and in the development of standards for *gari* and other cassava products.

Quality Management Systems are used to manage the processes and activities that transform inputs or raw materials into a product, such as *gari*, which meets the processors' objectives while satisfying the customer's quality requirements, complying with regulations, and meeting environmental and public health objectives.

From the public health and nutrition standpoint, the purpose of any quality management system is to ensure the safety of consumers and the nutritional and organoleptic quality of the product. The implementation of a quality management system requires that the implementing team be made up of people who have the competencies to effectively execute both the technical and managerial components. The technical component deals with the practical application of the scientific concepts of quality management on the production line whilst the managerial component deals with planning, organizing, directing, and controlling the operation of the system.

The CODEX Alimentarius Commission (CAC) and various national standards bureaux have developed quality specifications for *gari* (see sample in Appendix I), to regulate the quality and safety of the product in the international market and to protect the health of consumers. These include the Ghana Standards Board (GSB), the Standards Organization of Nigeria (SON), and the Sierra Leone Standards Bureau (SLSB). In addition, a *gari* standard exists at the level of the CODEX Alimentarius Commission (CAC). In spite of these developments most *gari* producers are yet to be compliant because of their inability to integrate quality management systems into their production operations, either due to a lack of commitment, inadequate sensitization, or the absence of simple guide for quality management since most *gari* producers are not technically knowledgeable.

This book provides the processor with a simple step-by-step guide for quality management in *gari* production. The practical implementation areas covered include (1) good manufacturing practices (GMP) and good hygienic practices (GHP); and (2) compliance with a Hazard Analysis Critical Control Points (HACCP) quality management. The manual guides cassava processors on procedures for obtaining quality certification and registering the management practices used in the production process for *gari*. The manual will also be useful to food science and technology students, researchers, and those involved in food control programs.

II
Gari Production

Fresh cassava for gari production

Gari is processed from fresh roots of cassava (*Manihot esculanta* Crantz). The cassava roots must be produced using safe agricultural inputs and practices. A cassava variety that gives good quality *gari* must be selected. The roots should be harvested at maturity, depending on the variety, when the dry matter and starch contents are high and no deterioration or lignification of the roots has occurred. To prevent health hazards due to the contamination of fresh cassava, good hygiene conditions must be maintained from production to harvesting, transportation, handling, and storage, ensuring that the roots are not contaminated with chemical or biological residues. In particular, contamination by animal manure and feacal matter must be avoided during and after harvesting. Cassava roots may be transported from the farm in sacks made of jute, sisal, polyethylene, or polypropylene. Sacks of roots should be carefully handled to prevent damage or bruising and kept in ways that allow ventilation up to the time of processing.

How to make *gari*

Gari is made by peeling fresh cassava roots, then washing and grating, fermenting, dewatering or pressing, breaking of the cake, sifting, roasting, sieving or grading, and packaging. The quality of *gari* depends mostly on the quality of the cassava variety and how adequate the processing steps were taken. The descriptions of the processing steps are as follows:

Peeling: Freshly harvested cassava roots are peeled immediately after harvesting or at most, a day after harvesting. Peeling must be thorough to avoid the presence of peel fragments in the final product. Manual peeling with knife is most common but mechanical peelers have recently become available in a few countries such as Nigeria and Ghana. The practical significance of peeling is the removal of brown peel which might affect the color of the *gari* and increase fiber content.

Washing: Peeled roots are washed thoroughly in potable water to remove all sand particles and dirt, which could mar the quality of the final product.

Grating: Clean roots are grated to obtain a mash. Grating is carried out by means of a motorized cassava grater but hand graters, made by fastening the perforated grating sheets on wooden planks, are still used in some rural villages in some countries. A grating plate is made of a perforated metal sheet and with a sharp extruding face as the grating zone. The sharpness of the extruding zone affects the efficiency of subsequent operations such as fermentation and detoxification, and some quality characteristics of the final product such as fineness (Oguntimein et al. 1995). Grating disintegrates the cassava tissue and frees up the moisture so that mechanical dewatering can be done easily. Cassava starch granules are also partially released due to grating. In addition, the total surface area of the cassava tissue increases significantly, the endogenous linamarase enzyme is released and initiates the rapid enzymatic hydrolysis of the bound cyanogenic glucosides into their intermediate compounds. During grating of freshly harvested cassava, and before fermentation sets in, the pH is conducive for a spontaneous release of hydrocyanic acid (HCN) from the intermediate compounds, thereby detoxifying the cassava.

Fermentation: Grated cassava mash is loaded either into a polypropylene bag or basket (lined with polypropylene sack) and left for between 1 and 5 days to ferment, depending on the taste preferences of the targeted consumer. Fermentation of cassava is an important operation in terms of taste, aroma, safety, and general quality of *gari*. The acceptability of *gari* is influenced by its sourness, which is related to the amount of lactic acid or length of fermentation. Consumers in the south-east of Nigeria and most parts of Ghana accept a mild, sour taste while in the

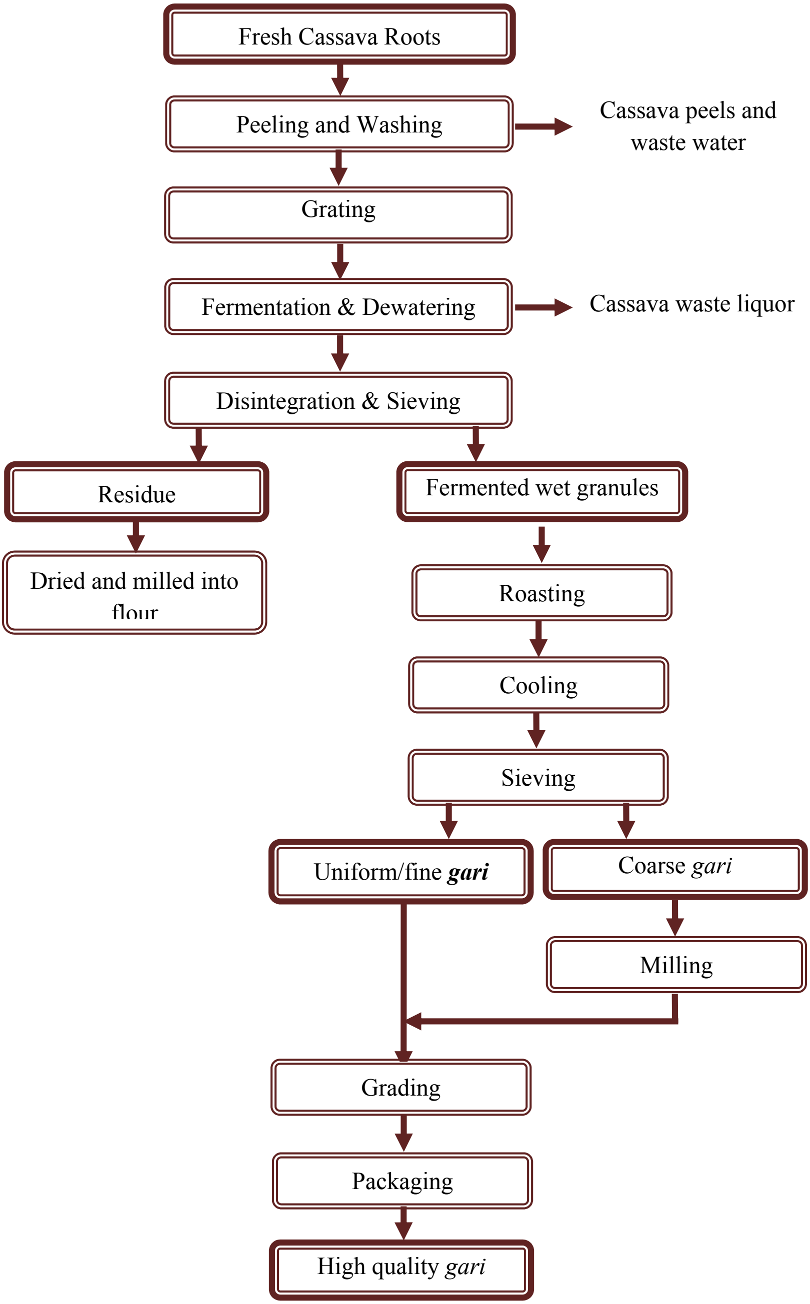

Figure 1. Flow chart for the production of *gari*.

south-west of Nigeria they prefer an acidic taste. In order to get the acidic taste, the cassava mash is fermented longer (3-5 days) than in south-east Nigeria (1–2 days). Cassava fermentation for *gari* production occurs through the activities of endogenous microorganisms, mostly lactic acid bacteria, producing lactic acid that reduces the pH of the fermenting mash. The following lactic acid bacteria have been suggested as being responsible for the acidification process: *Lactobacillus* spp., *Streptococcus*, *Corynebaterium*, and *Leuconostoc* (Meraz et al. 1992). Heat is produced in the fermenting mash and pH decreases from near neutral (6.9) to 4.0 or less in 3-5 days of fermentation. The longer the fermentation period the lower the pH of the mash or more sour the *gari* becomes. In addition to the acids, some other flavor compounds (pyrazines, aldehydes, esters, aldehydes, ketones, alcohols, etc) are produced by the fermenting bacteria and fungi. These compounds contribute to the aroma developed during *gari* roasting. Therefore the characteristic flavor of *gari* is mostly due to the combination of fermentation and roasting.

Recent increased scientific knowledge about the precise mechanism of the hydrolysis and removal of cyanogenic glucosides in cassava has enabled scientists to determine the best procedures for enhancing the safety of *gari* and other cassava products. The earlier belief that fermentation action was responsible for removal of cyanogens in *gari* has been replaced with more accurate knowledge. Cassava detoxification during *gari* processing may occur from grating and continue simultaneously with fermentation until after roasting, it is not necessarily caused by fermentation. Detoxification is mainly as a result of the hydrolysis of linamarase (endogenous cassava enzyme) on cyanogenic glucosides (linamarin and lotaustralin) when the cassava tissue cellular structure is damaged through grating. Cyanohydrins produced from the hydrolysis further break down automatically at neutral pH. The cyanohydrins and the smaller compounds are either removed during pressing or they volatilize continuously even after roasting. *Gari* processing operations, especially grating, fermentation, dewatering, and roasting, if properly done will ensure that the cyanogens are removed to safe levels irrespective of the variety of cassava used.

Dewatering: The fermented mash is dewatered inside a polypropylene sack by pressing with a manual screw or hydraulic press. Pressing is done principally to reduce the moisture content of the grated mash to 40-50%. Dewatering could be completed within a short time, 15–20 minutes, when high capacity hydraulic systems are used. Simultaneous fermentation and gradual dewatering of cassava mash in a polypropylene bag is also done in some communities. The dewatering operation contributes to cassava detoxification through the elimination of cyanogens, cyanohydrins in particular, with the waste liquor. Dewatering has to be done to the optimum moisture content for proper dextrinization during roasting.

Disintegration and Sieving: The cake formed after dewatering is disintegrated or granulated by a hand-held motorized cassava grater. The cake could also be broken up by hand and sieved with a manual woven sieve or rotary sieve, to remove the fiber and lumps (pieces of improperly grated cassava). The improperly grated cassava pieces could be returned to the grater for proper grating or processed further into other types of cassava products. Sieving reduces the formation of lumps during roasting.

Roasting: The roasting process, otherwise known as "garification" is done immediately after sieving. An earthenware stove and a frying pan made of molded aluminum or stainless steel are used, often on a wood fire. In some communities, the roasting pan is smeared with a small amount of shea fat or palm oil prior to roasting. The granules are fed in bits into the hot pan and stirred until an adequate quantity has been fed in. The use of mechanical fryers has become very common in Nigeria. Roasting is understood to be a two-step operation. The first stage is partial gelatinization or dextrinization, followed by drying. The stirring of *gari*, during roasting is continuous but with intermittent short breaks which allow proper gelatinization to occur. The *gari* is collected when it is dry and the color becomes creamy. A small amount is often left in the pan to facilitate the roasting of the next batch. *Gari* flavor develops and become very strong during the roasting or gelatinization stage. The gelatinization improves the digestibility of *gari* while the extent of dryness determines the crispiness of *gari* and the storability. The final moisture content of *gari* is 8–10%.

Cooling: Roasted *gari* is allowed to cool for 4-6 hrs in clean containers. As the *gari* cools, it loses more moisture so becoming drier and more crisp.

Sieving (Grading): Depending on the preference of consumers, the roasted *gari* may be sieved to remove big lumps and obtain uniform particle sizes. The coarse granules or lumps are sometimes milled to smaller particle sizes which are either used separately or mixed with the main batch depending on the fineness after milling.

Packaging: The final product is packaged in unit packages of 1, 5, 10, 25, and 50 kg depending on the distribution outlet. The packaging material is either polyethylene bags for small unit packaging or polyethylene-lined polypropylene sacks for the larger sized packages. Packing is done soon after the *gari* has sufficiently cooled. Packing in moisture impermeable bags before adequate cooling (and moisture loss) or too late after the *gari* has re-absorbed moisture will significantly reduce the shelf life of *gari*. *Gari* that is properly packaged under the above conditions can be stored for at least a year, as long as the polyethylene lining in the package is not broken. Without the polyethylene lining the product absorbs moisture, loses its crispiness, and is prone to mold growth. Packaged *gari* should be stored in well-ventilated rooms on pallets.

Intended use and method of use

Gari can be eaten in granular form. In West Africa, it is soaked in cold water with a mixture of sugar, milk, and/or salt. The soaked *gari* is drank with groundnut, fish, meat or soup/stew/gravy made from protein sources such as beans, meat, and fish. *Gari* is also mixed with cooked beans for consumption. It is mixed in boiled water to make a dough (*eba*) that is served with a meat/fish stew or soup.

Processing machinery and plant

In the last three decades, notable advances have been made in the design and fabrication of *gari* processing machines. The old methods of *gari* processing involved hand grating cassava roots, dewatering cassava mash by placing the bag containing grated cassava mash in-between poles tied together with heavy ropes to exert sufficient pressure to squeeze the water out. Heavy planks and stones were also used for dewatering while frying or roasting was done by women and children in earthenware pots in highly smoky environments. These unit operations were very laborious and time wasting and exposed the processors (especially women) to many health risks including physical injuries from hand graters and heavy stones that fell off from bags of cassava mash being pressed.

New and more efficient machines are now available for cassava processing into *gari* and other products. More efficient and high capacity cassava graters, hydraulic operated dewatering machines (pressers), and stoves with stainless steel fryers and chimney, etc. have been developed. In addition, harvesters, fresh cassava peelers, mechanical fryers, etc. have been introduced in the last eight years. A new innovation for combining grating and pressing in a single operation is being developed by researchers in Nigeria (Kolawole et al. 2012).

The availability of different types of machines of varying capacities for *gari* processing has increased the efficiency of mechanized *gari* processing operations. The mechanized operation has significantly reduced labor input, processing time, and health risks for processors. It has also increased the quality of *gari*, the output of *gari* per unit time and flexibility in terms of scale of operation for investment in *gari* processing plants and machinery.

The procedure for selecting *gari* processing sites, constructing the processing building, and selecting and laying out the machinery is similar to the approach described for the HQCF plant (Dziedzoave et al. 2006). Peeling fresh cassava is done outside the processing floor where other unit operations are carried out. The wet and dry operations are done in different areas of the processing plant and are demarcated. A typical design of *gari* processing plant is shown in Figure 2.

Gari processing plants must be located close to the source of fresh cassava with minimal transportation of roots to the processing plant. Supply of major inputs such as water, labor, electricity, and ease of transporting *gari* to the market must be considered in the choice of location. A standard design of food processing plants must be used and machinery should be placed in the same sequence as the unit operations for *gari* processing. Frying stoves must be placed in a well-ventilated location. Normally, the work area from frying to grading and packing is separated from the wet operations.

Quality and safety factors

Gari should be safe and suitable for human consumption, and free from abnormal flavors, odors, and living insects. *Gari* must be free from filth (impurities of animal origin, including dead insects) in amounts which may represent a hazard to human health.

Different countries often indicated specific quality and safety requirements for *gari* (See sample in Appendix I). Generally, total hydrocyanic acid content of *gari* must not exceed 10 mg/kg while total fiber and ash should not exceed 2% m/m and 2.7% m/m, respectively. The maximum moisture content of *gari* should be 12% while a total acidity of 0.6–1.0 % m/m is acceptable. For the purposes of export or long-distance marketing, lower moisture limits may be required for certain destinations depending on the climate, packaging method, duration of transport, and storage.

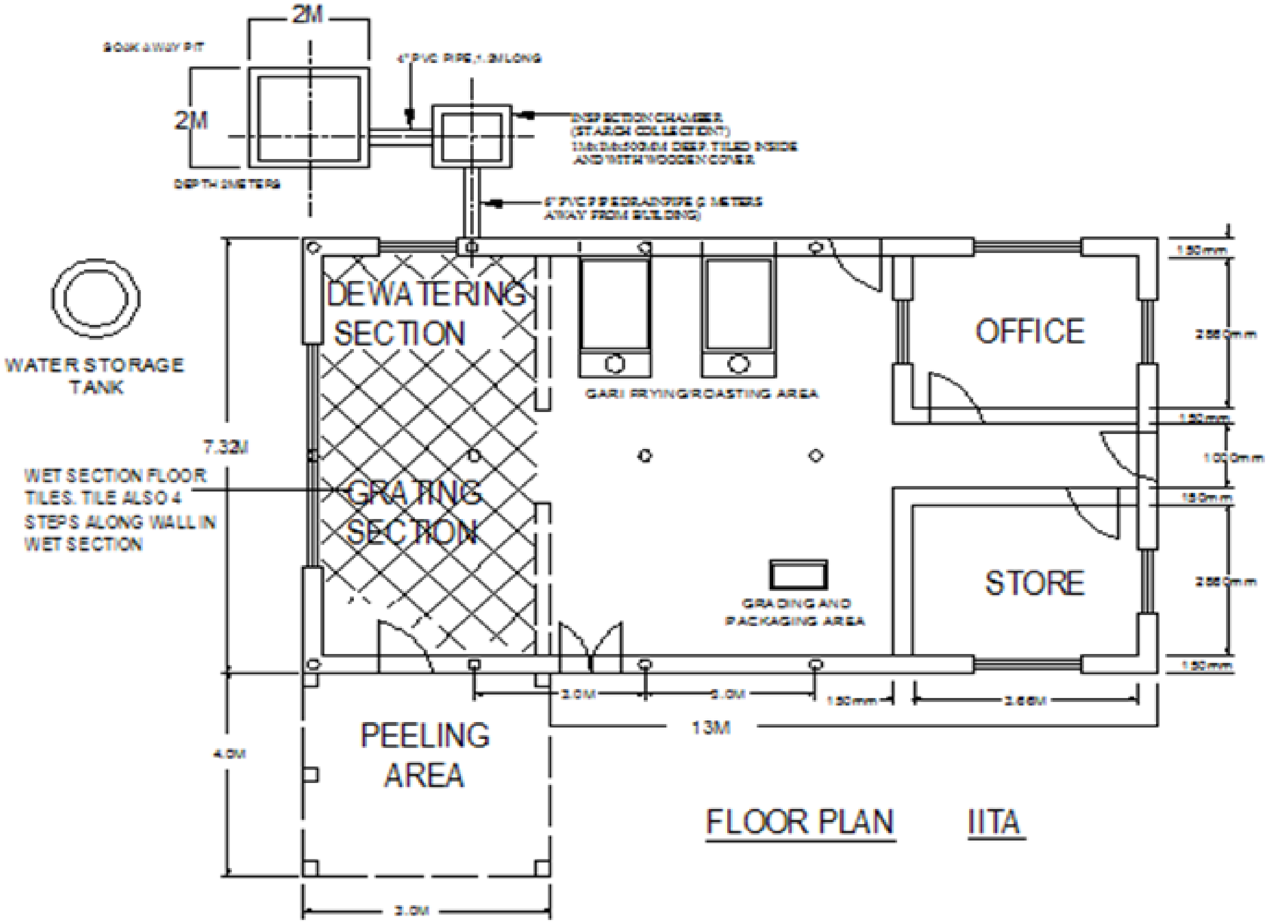

Figure 2. Floor plan of small-medium scale *gari* processing plant.

In Nigeria, the inclusion of food additives such as palm oil, vitamins, proteins, and other nutrients are allowed for enrichment. Salt and edible fat or oil may be added to *gari* in appropriate amounts. In all cases additives must conform to the legislation of the country in which the *gari* is consumed or sold. *Gari* should conform to the maximum mycotoxin and residue limits established by the Codex Alimentarius Commission and be free from heavy metals in amounts which may represent a hazard to human health.

General steps of food hygiene must be maintained in processing and handling of *gari* (CAC/RCP 1-1969, Rev. 2-1985, Codex Alimentarius Volume 1B), ensuring that *gari* is free from objectionable matter, parasites, microorganisms or their metabolites in amounts which may represent a hazard to health. Most traded *gari* is unclassified. In Nigeria and Mozambique, *gari* is graded into three to five classes: extra-fine (at least 80% of the weight passes through a 355-micron aperture sieve; fine *gari* (at least 80% of the weight passes through a 1000 micron-sieve with apertures but of which less than 80% of the weight passes through a 355-micron aperture sieve. For coarse *gari*, more than 80% of the weight passes through a 1.4 mm aperture sieve but of which less than 80% of the weight pass through 1 mm aperture sieve, and 20% of the weight of extra coarse *gari* passes through 1.4 mm aperture sieve.

Gari must be packaged in suitable containers or packaging materials. The packaging materials should be chosen on the basis of suitability to safeguard its hygienic, nutritional, technological, and organoleptic qualities. The containers, including packaging material, shall be made of substances which are safe and suitable; must not impart any toxic substance or undesirable odor or flavor to the *gari*. Sacks for packing *gari* must be clean, sturdy, and strongly sewn or sealed. *Gari* packages must be labeled and the name, *gari*, has to appear on the label (CODEX STAN 1-1985, Rev. 1-1991, Codex Alimentarius Volume 1A). Similarly, the lot identification number, name and address of the manufacturer/packer or identification mark must be indicated on the retailer package.

III

Hazard/Quality Analysis Critical Control Points System for *Gari* Production

The critical control points system for *gari*

The Hazard analysis critical control point (HACCP) system for controlling and ensuring food safety is a scientific and systematic approach to identifying hazards and providing measures for their control to guarantee food safety. With HACCP the safety of food is assured through monitoring and controlling of materials, and processes which could lead to a compromise in the safety of the final food products. To ensure that the quality of food products is also taken into consideration during processing, the Quality analysis critical control point (QACCP) system has been developed to address quality as well as the safety of products (Dziedzoave et al. 2006).

Implementing a HACCP/QACCP management system

For the successful implementation of the quality systems outlined above for *gari* production, it is important to put in place a rigorous management system to ensure adherence to the steps outlined and the documentation of all data and information, with responsibilities clearly outlined and delineated. The following steps are proposed for the establishment of a good management system.

- Constitute a quality team to oversee both the implementation of the HACCP/QACCP and the GMP/GHP (good management practice/good hygienic practice) steps.
- Assign responsibilities to each member of the quality team.
- Develop schedules for reporting by each member of the quality team.
- Undertake regular training and re-training of staff in the following areas:

  - Understanding of HACCP and hazards associated with *gari* production.
  - *Gari* production, handling, packaging, and storage.
  - Hygienic conduct and basic food hygiene.
  - Maintenance and sanitation of buildings and structures.
  - Cleaning procedures for equipment and environment of food processing plants.
- Have periodic external audits of the quality system
- Undertake regular management reviews of the quality system involving a review of the latest:
  - Management review report
  - External audit report
  - Monitoring reports
  - Verification reports
  - Corrective action reports and improvements instituted
  - Customer complaints etc.

Quality team

The team should comprise the following:

- An external technical and independent advisor on HACCP/ QACCP
- Operations or Production Manager
- Quality Assurance Manager
- An Agronomist

At least one of them should have Food Science/ Microbiology or Food Chemistry/ Biochemistry background.

- Engineer, Equipment or Machinery Technician
- Marketing/Distribution Manager
- Supporting Junior Staff

However for small- to medium-scale enterprises where all the above expertise may not be available, the team could be made of:

- An external technical and independent advisor on HACCP/ QACCP
- The Plant Manager
- The Production Supervisor
- Quality Assurance supervisor
- Supporting Junior Staff.

The team should have responsibility for managing the implementing quality system and addressing all the management issues outlined above. The team should meet regularly (possibly once every month) to review performance of the quality mandate and maintain the consciousness of the entire workforce to quality and safety.

The seven steps for implementing the HACCP/QACCP system for *gari*

There are seven steps underlying the implementation of a HACCP/QACCP system. These are:

Step 1: The identification of Potential Hazards/quality defects associated with *gari* production.

Step 2: Establishing critical control points (CCPs) for *gari* production.

Step 3: Establishing critical limits for each of the CCPs.

Step 4: Establishing a monitoring system.

Step 5: Specification of corrective actions to be taken when processes are out of control.

Step 6: Establishing a procedure for verification of effectiveness of the system.

Step 7: Documenting and keeping records of all the activities related to the implementation of the system.

Step 1. Identify potential hazards/quality defects associated with *gari* production

The potential hazards/quality defects are the identified areas within the production process which could either create a safety problem for consumers or rejection of the product by consumers on grounds of quality.

Potential Hazard or Quality Defect

- Over-aged roots.
- Spoilt cassava roots.
- Cyanogens in high cyanide varieties.
- Pathogenic organisms in water used for washing cassava roots.
- Sand left on washed roots.
- Pathogenic thermophiles from unclean or improperly cleaned machines (e.g., graters).
- Excessive acidity in fermented mash.
- Residual cyanogens in pressed cassava cake.
- Pathogenic organisms (thermophiles) from animal droppings in unclean and unhygienic pressing environment or dirty sacks.
- Pathogenic organisms from unclean fermentation troughs, or animal droppings in unclean environment.
- Pathogenic organisms from unclean hands.
- Contamination of food products with rust in roasting pans.
- Underweight packages due to leakages resulting from damage to package or improper sealing of packaged products.
- Moisture absorption by products due to leakages or improper packaging material such as use of moisture permissible materials.
- Weevil infestation of packaged products.

Step 2. Establish critical control points (CCPs) for *gari* production

The critical control points are the specific processing steps which when properly managed can help eliminate or minimize the occurrence of the identified hazard or quality defect. In other words, they are the unit operations where each of the above identified hazards and quality defects could easily occur. They are qualified as CCP_1, CCP_2 etc. For *gari* production these are outlined in Table 1.

Step 3. Establishing critical limits for each control measure for the CCPs

Control measures are actions that must be taken at each CCP to prevent or minimize the occurrence of the potential hazard. The critical limits are target levels and tolerances which should be met at each CCP in relation to the identified hazards to ensure that the CCPs are under control to produce gari that meets the expected quality specifications. For gari the critical limits to be met by the control measures as an indication of adequate controls at each CCP are detailed in Table 2.

Table 1. Critical control points for *gari.*

Critical control point	Unit operation	Potential hazard or quality defect
CCP1	Fresh cassava roots delivery	• Over-aged roots. • Spoilt roots. • High cyanogens in cassava varieties delivered.
CCP2	Washing of tubers	• Pathogenic organisms in water used for washing cassava roots. • Sand left on washed roots.
CCP3	Grating	• Pathogenic thermophiles from unclean or improperly cleaned graters.
CCP4	Fermentation	• Pathogenic organisms from unclean fermentation troughs, or animal droppings in unclean environment. • In adequate acidity due to shortened fermentation. • Excessive acidity due to over-fermentation.
CCP5	De-watering/ Pressing	• Residual cyanogens in pressed cassava cake. • Pathogenic organisms (thermophiles) from animal droppings in unclean and unhygienic pressing environment or dirty sacks.
CCP6	Cake breaking/ Disintegration	• Pathogenic organisms from unclean hands.
CCP7	Roasting	• Contamination of food products with rust in roasting pans.
CCP8	Packaging	• Underweight packages due to leakages resulting from damage to package or improper sealing of packaged products. • Moisture absorption by products due to leakages.
CCP9	Storage	• Weevil infestation of packaged products.

Table 2. Critical limits for each CCP.

Critical control point (CCP)		Significant hazard/ Quality defect	Control/preventive measure	Critical limits for control measure
CCP number	Unit operation			
CCP_1	Fresh cassava	Over-aged roots	Select roots of appropriate variety and age.	Cassava should normally be 10−12 months old at harvest. In few cases, some varieties mature in 15−18 months.
CCP_1		Spoilt cassava roots	Process soon after harvesting	Process within 8−12 hours of harvesting.
CCP_2	Washing	Pathogenic organisms in water used	Use potable water from credible source. Treat water from all other sources before use.	Complete absence of dirt, fecal matter, or offensive odor in water supply. pH: 6.5-8.5 conductivity: 5-80 mS/m or 250-400 ppm density: 990−1000 kg/m^3 chlorine: 0.2–1 mg/liter
CCP_2		Sand left on washed roots	Ensure that sticky mud and sands are completely removed from all parts and roots' contours.	Complete absence of sand or mud on washed roots.
CCP_3	Grating	Pathogenic thermophiles	Use clean grating machines. Ensure graters are washed before and after end of daily operation.	Complete absence of dirt inside and outside grating machines.
CCP_3		Residual cyanogens	Grate finely.	Absence of lumps of cassava roots.
CCP_4	Fermentation	Pathogenic organisms from unclean fermentation troughs or sacks, or animal droppings in unclean environment.	Clean fermentation troughs and tables daily. Disinfect fermentation troughs or sacks regularly.	Complete absence of dirt, animal droppings or droppings from houseflies in fermentation troughs.
		Inadequate or excessive acidity	Ferment for the appropriate duration to produce the level of sourness acceptable to the target consumer.	Fermented mash of pH range 4.0 to 5.5 will produce *gari* with sourness liked by different categories of consumers. The pH suitable for the level of *gari* sourness desired by each category of consumers must be established by each processor.
CCP_5	De-watering	Residual cyanide	Efficient dewatering to remove liquor with high amount of cyanogens.	Less than 55% moisture level of pressed cake
CCP_5		Pathogenic thermophiles	Use clean (disinfected) polypropylene sacs and clean dewatering machine/press. Avoid contact of pressing sacks with dirty surfaces/soil Wash and dry all sacks at the end of each day's work, treat all sacks with hot water and/or disinfectant weekly.	Complete absence of dirt on sacks and dewatering equipment.

Table 2. Contd.

CCP_6	Disintegration	Pathogenic organisms from unclean hands or disintegrating tools (grating machine or sifters) and containers.	Wash hands thoroughly with soap before disintegration Use clean grating machines, sifters, and containers. Ensure graters and containers are washed before and after end of daily operation.	Washing of hands in accordance with the GMP steps. Complete absence of dirt inside and outside grating machines and containers or on sifters.
CCP_7	Roasting	Contamination of food products with rust and other contaminants in roasting/frying pans. Wet or improperly cooked *gari* that may support rapid growth of mold (causing spoilage) in storage	Use stainless steel or cast aluminum roasting/frying pans, or grease roasting pans with vegetable oil when not in use. Wash roasting/frying pans before and after use. Roast with adequate heat and for sufficient time duration to cook properly until *gari* is crispy and dry before removing from frying pan. Allow to cool sufficiently before packaging but not too long to avoid moisture absorption.	No observable evidence of rust in roasting pans prior to roasting. No dirt in the roasting/frying pans before use. Well-cooked and crispy *gari* with max moisture content of 10−12%. Allow to cool for 6 hrs or less before packaging.
CCP_8 CCP_8	Packaging of *gari*	Underweight packages due to leakages resulting from damage to package or improper sealing. Moisture absorption by *gari* or contamination of *gari* due to leakages.	Good sealing (sewing, gumming, etc) of *gari* packages (polyethylene-lined paper, polyethylene, cotton or polypropylene bags, and cardboard boxes. Cotton, paper, and polypropylene sacks should be lined inside with thin polyethylene bag.	No observable openings after sealing of packages. No observable damage to package or product spill. *Gari* not exposed to air or contaminants. Hermetical seal.
CCP_9	Storage	Weevil infestation of packaged products.	Regular fumigation of storerooms and entire processing area. Inspection of unit packages during storage.	Once every three months. No observable insects in packages.

Step 4. Establish a monitoring system

A monitoring system defines what must be monitored, how it is to be monitored, the frequency of monitoring, and who does the monitoring. For *gari* production these would be done as shown in Table 3.

Step 5. Specify corrective actions to be taken when processes are out of control.

Corrective actions indicate the actions that must be effected as soon as the results of the monitoring process show that any particular CCP is deviating from its specified critical limits. Some suggestions are presented in Table 4.

Step 6. Establish a procedure for verification of effectiveness of the system

Verification implies taking samples of products and undertaking a laboratory analysis of these samples to confirm results of the monitoring process and affirm the relevance or otherwise of the corrective actions. Verification procedures for *gari* production are listed in Table 5.

Table 3. Sample monitoring system for gari production.

Critical control point (CCP)		Significant hazard/ Quality defect	Monitoring				
CCP number	Unit operation		What	How	Frequency	Who	Records
CCP$_1$	Fresh cassava	Over-aged roots	Variety name, maturity (months) before harvest.	Investigate from seller.	Every batch	Quality Assurance Manager	Name of variety, Age at harvest, Date and time of harvest.
			Date and time of harvest.				
CCP $_1$		Spoilt cassava	Color change; evidence of spoilage; presence of vascular streaking; presence of brown streak.	Visual inspection	Every batch	Quality Assurance Manager	Degree of discoloration
			pH.	pH meter			pH
CCP $_2$	Washing	Pathogenic organisms in water used.	Dirt in water: particulate matter, sand, and fecal matter; odor; pH Conductivity;	Visual inspection	Daily	Production Supervisor	Levels of dirt particulate matter, sand, fecal matter odor, pH, and conductivity of water.
			Density;	Smell.			
			Chlorine.	pH meter			
			Washed roots: sand particles or mud	Conductivity meter.			
				Densitometer			
		Sand left on washed roots		Visual inspection			Presence or absence of sand and mud particles on washed roots
CCP $_2$					Every batch of peeled roots		

Table 3. Contd.

CCP $_3$	Grating	Pathogenic thermophiles	Dirt on grating machines.	Visual inspection.	Before grating.	Production Supervisor.	Absence of dirt or rotten cassava mash from grating operation done more than 24 hrs previously.
CCP$_3$		Residual cyanogens	Variety of cassava.	Enquire from supplier,	Before harvesting and prior to processing.	Quality control supervisor.	Name of variety.
			Taste of cassava.	Sensory tasting.			Taste of cassava.
			Qualitative cyanogen level in cassava.	Use picrate paper and color guide (See appendix)			Cyanogen level.
CCP$_4$	Fermentation	Pathogenic organisms from unclean fermentation troughs or sacks;	Dirt in fermentation troughs.	Visual inspection	Before Fermentation	Production Supervisor	Absence of dirt.
			Animal droppings,	Visual inspection		Production Supervisor	Absence of animal droppings.
		Animal droppings in unclean environment.	Droppings of any animal (e.g., houseflies)	Visual inspection		Production Supervisor	Absence of animal droppings.
		Acidity	Acidity	Acidity paper or pH meter.	During and after fermentation	Quality control supervisor	pH
CCP $_5$	De-watering	Residual cyanogens	Degree of dryness of pressed cake	Finger press-feel of pressed cake and/or rapid moisture meter.	every 10 min of pressing, every batch	Press operator.	Hard finger-feel of pressed cake and/or moisture content.
CCP $_5$		Pathogenic thermophiles	Dirt on dewatering equipment and pressing sacks.	Visual inspection.	Before, during, and after dewatering.	Quality control Supervisor.	Absence of dirt.

Table 3. Contd.

CCP_6	Disintegration	Pathogenic organisms from unclean hands, sifter or grater.	Adequacy of hand washing by staff; cleanliness of machine, containers, and sifter.	Visual inspection	Before and after disintegration.	Production Supervisor	Level of cleanliness of hands, machine, container and sifter
CCP_7	Roasting	Contamination of food products with rust in roasting pans.	Evidence of rust or dirt in roasting/ frying pans.	Visual inspection	Before and after roasting	Production Supervisor	Degree of rusting and cleanliness observed in roasting pans.
		Dryness of *gari*	Crispiness	Visual inspection and hand feel	After roasting		Crispiness (Dryness)
CCP_8	Packaging of *gari*	Underweight packages due to leakages resulting from damage to package or improper sealing.	Wholeness and integrity of packages.	Inspection of each unit package.	Before and after every packaging operation.	Packaging operator.	Identity of packages with leaks or damaged.
		Moisture absorption by *gari* due to delay in packaging or leakages of packages.					
CCP_8			Crispiness of batch of *gari*, and wholeness and integrity of packages.	Inspection of each batch of *gari* to be packaged and each unit of package.	Before and after every packaging operation.	Packaging operator	Batch number of *gari* to be packed, and identity and number of packages with leaks or damaged.
CCP_9	Storage	Weevil infestation of packaged products	Last fumigation date.	Inspection of fumigation records.	Monthly	Production Manager.	Number of insects observed in each unit package.
			Presence of weevils in packages.	Visual inspection.	Every two weeks.	Stores supervisor.	Number of packages with insects within.
			Presence of weevils in and around packaging and storerooms	Visual inspection.			Number of insects found per unit area of processing area.

Table 4. Corrective actions for deviating critical control points of *gari* production.

Critical control point (CCP)		Significant hazard/ Quality defect	Corrective action
CCP number	Unit operation		
CCP_1	Fresh cassava	Over-aged roots	Reject unwanted variety, over-aged or discolored roots.
CCP_1		Spoilt roots	Redirect unprocessed roots supplied more than 12 hrs after harvesting into other fermented cassava products or into chips for animal feed.
CCP_2	Washing	Dirty water or pathogenic organisms in water used.	Change the water for washing or the source of water.
CCP_2		Sand left on washed roots	Alert staff washing/operating washing machine (if any), to rewash.
CCP_3	Grating	Pathogenic thermophiles	Clean and sanitize graters before and after use.
CCP_3		Residual cyanogens.	Grate cassava properly; avoid lumps in grated cassava mash
CCP_4	Fermentation	Pathogenic organisms from unclean fermentation troughs, sacks or animal droppings in unclean environment.	Clean and sanitize fermentation troughs and sacks before and after use.
CCP_5	De-watering	Cyanogens	Repeat or continue de-watering operation by increasing pressure of pressing machine during pressing operation.
CCP_5		Pathogenic thermophiles	Clean and sanitize sacks. Re-wash pressing machine.
CCP_6	Disintegration	Pathogenic organisms from unclean hands, machine, containers and sifter.	Instruct staff to re-wash hands and de-watering tools thoroughly with soap and water.
CCP_7	Roasting	Contamination of food products with rust and other contaminants in roasting/ frying pans.	Clean off dirt and rust, and grease pan with vegetable oil.
CCP_8	Packaging of *gari*	Underweight packages due to leakages resulting from damage to package or improper sealing.	Repackage defective products.
CCP_8		Moisture absorption by product due to leakages.	Repackage defective products.
CCP_9	Storage	Weevil infestation of packaged *gari*.	Fumigate plant. Sift and re-dry defective products in mechanical dryer and repackage for immediate supply to non-food end-users.

Table 5. Verification procedures.

Critical control point (CCP)		Significant hazard/Quality defect	Verification
CCP number	Unit operation		
CCP_1	Fresh cassava	Over-aged roots	Moisture content, starch content, discoloration by color chart (use munsel color book), pH.
CCP_1		Spoilt cassava	
CCP_2	Washing	Pathogenic organisms in water used.	Carry out a microbiological assessment of samples of water and final products: Pathogens, Coliforms, total plate count.
CCP_2		Sand left on washed roots	
CCP_3	Grating	Pathogenic thermophiles	Microbial analysis of final products and swaps from equipment: pathogens, coliforms, total plate count.
CCP_3		Residual cyanogens	Quantitative analysis of cyanogens' level of product.
CCP_4	Fermentation	Pathogenic organisms from unclean fermentation troughs, sacks or animal droppings in unclean environment.	Microbial analysis of final products and swaps from fermentation trough and sacks: pathogens, coliforms, total plate count.
CCP_5	De-watering	Cyanogens	Moisture content (oven method) Total cyanogens content of pressed cake.
CCP_5		Pathogenic thermophiles	Microbial analysis of final products and swaps from sacks and equipment: pathogens,coliforms, total plate count.
CCP_6	Disintegration	Pathogenic organisms from unclean hands, machines and containers.	Microbial analysis of final products: pathogens, coliforms, total plate count.
CCP_7	Roasting	Contamination of food products with rust in roasting pans.	Ash content of final products.
CCP_8	Packaging of *gari*	Underweight packages due to leakages resulting from damage to package or improper sealing.	Sample and weigh packages in store.
CCP_8		Moisture absorption by product due to leakages	Sample packages and check moisture content.
CCP_9	Storage	Weevil infestation of packaged products	Sample and check for number of insects and microbial load.

Step 7. Document and keep records of all the activities related to the implementation of the system

All the procedures followed for the implementation of the HACCP/QACCP system should be documented; results of observations and tests must be recorded, and all the records kept up-to-date in an accessible manner. The relevant record forms for gari production are shown below.

Form 1. Monitoring of results

Date: ....

Batch no: ....

Recorded by: ....

CCP	Examination Parameters	Results
Fresh Cassava CCP_1	• Cassava maturity at harvest • Variety of cassava • Date of harvest • Time of harvest • Date of delivery • Time of delivery • Appearance: Degree of discoloration or vascular streaking • pH of roots	
Washing CCP_2	Visual Examination • Dirt in water • Particulate matter in water • Sand in water • Color of water • Odor of water • pH of water • Conductivity of water • Density of water • Sand particles on washed roots • Mud on washed roots	
Grating CCP_3	• Dirt on grating machines • Variety of cassava (sweet or bitter) • Qualitative level of cyanogens	
Fermentation CCP_4	• Dirt in fermentation troughs and sacks • Animal droppings in fermentation tools • Droppings of houseflies in troughs and sacks	
Dewatering CCP_5	• Feel of moisture level in pressed cake • Dirt on dewatering equipment • Dirt on sacks	

Disintegration CCP_6	•	Pathogenic organisms from unclean hands
	•	Ambient temperature
Roasting CCP_7	•	Level of rust in roasting pans
Packaging CCP_8	•	Number of packages improperly sealed (ie leaking)
Storage CCP9	•	Last fumigation date
	•	Number of insects (weevils) or insect parts observed in each packaged unit
	•	Number of weevils in and around storerooms
	•	Number of packaged units with insects or insect parts within.

Form 2. Corrective actions taken

Date	CCP	Critical limit exceeded	Action taken
	CCP_1		
	CCP_2		
	CCP_3		
	$CCP_{,,,}$		
	CCP_n		

Form 3. Verification results

Date: ……………………………………………………

Labooratory:……………………………………………………..

Approved by:……………………………………………………..

Reference material	Analysis	Result
Fresh cassava	• Moisture content (%) • Starch content (%) • pH • Color of inside flesh • CNP (mg/kg)	
Water and washed roots	• Pathogens (cfu/g) • Coliforms (cfu/g) • Total plate count (cfu/g) • Extraneous matter	
Fermented pressed cake	• Moisture content of pressed cake • CNP of pressed cake (mg/kg) • CNP of final product (mg/kg) • Total plate count (cfu/g) • Yeast and mold (cfu/g) • Coliforms (cfu/g) • *E. coli* (cfu/g) • Salmonella (cfu/g) • Shigella (cfu/g)	
Surface hygiene swabs from fermentation troughs, dewatering equipment, and sacks	• Total plate count (cfu/g) • Yeast and Mold (cfu/g) • Coliforms (cfu/g) • *E. coli* (cfu/g) • Salmonella (cfu/g) • Shigella (cfu/g)	
Disintegrated cake	• Total plate count (cfu/g) • Coliforms (cfu/g) • *E. coli* (cfu/g) • Salmonella (cfu/g) • Shigella (cfu/g)	
Roasted *gari*	• Moisture content (%) • Ash content (%) • Fiber content (%) • Total HCN (Cyanide content; mg/kg) • Particle size distribution • Total acidity (%) • pH • Extraneous matter	
Packaged products	• Weight of selected samples of packages in store (g) • Microbial loads (cfu).	
Stored products	• Moisture content (%) • Extraneous matter	

IV

Good Manufacturing/Hygienic Practices (GMP/GHP) for *gari* Production

The steps of GMP/GHP relate more to the hygiene of personnel and the cleanliness and sanitation of the facilities employed in the production process; unlike the HACCP/QACCP which relate more to the raw materials, and intermediate and final products as well as the production processes used in turning out the products. They comprise rules and regulations that must be observed in the following key areas:

- Personal hygiene
- Cleanliness and sanitation of processing environment and equipment
- Management and control of rodents, insects, reptiles, and domestic animals.
- Waste management
- Plant layout and design

The following are the implementation procedures

Personal hygiene

- Staff should maintain a high degree of personal hygiene and cleanliness always.
- Sick or injured personnel should not handle food and should be made to undergo a medical examination.
- Health conditions like diarrhea, vomiting, fever, skin lesions, jaundice and discharge from the ear, eye or nose must be reported to management.
- Cuts and wounds must be covered with waterproof dressings.
- Hand washing sinks/basins with running water and soap should be provided within and outside the processing plant.

- Personnel must wash hands under the following circumstances:
  - At the start of processing activities.
  - At the end of every unit operation and before commencing another unit operation.
  - Immediately after using the wash room.
  - After handling unpeeled cassava or any material which could lead to contamination of *gari*.
- Personnel must not smoke, spit, chew gum, sneeze, or cough over unprotected food.
- Personal effects such as jewellery, watches, pins, bracelets, bands etc. should not be worn during processing.
- Personnel must wear protective clothing (overalls, head covers, nose masks, soft shoes, and gloves during all processing activities).
- Visitors must wear protective clothing and adhere to all personal hygiene requirements.

Cleanliness and sanitation of processing environment and equipment

Cleaning aids

- Stiff and soft brooms
- Hard and soft brushes
- Mops and buckets
- Vacuum cleaners with accessories
- Net sponges and mechanical scrubbers
- Squeegees
- Sweeping brushes
- Long-handled brushes
- Water hoses
- Dusters
- Cleaning chemicals—detergents, soaps, disinfectants, quaternary ammonium compounds etc.

Knives, pans, or bowls

- Wash knives, pans, bowls with soap buffed into sponge and with water.
- Scrub internal and external sections of bowls and pans with sponge and soap in water.
- Rinse off soap with copious quantity of water after scrubbing and allow water to drain off leaving bowls, pans and knives dry after a few minutes.
- Cleaning should be done before and after every operation.
- (Precaution: Caustic soda should not be used to wash aluminum surfaces).

Cassava grating machines

- Using brushes or sponges, wash off residues of cassava from outlet chute, hopper, and rinse off by spraying water with hose.
- Disassemble grating compartments at the close of daily operation and clean off all grated cassava residues using brushes and water. Leave to dry after cleaning before reassembling. Avoid entry of water into motor or engine of machine.

Mechanical dewatering machines or presses

- Scrub the bottom, side, and upper plates of dewatering machines using brush with water and soap to remove drained liquor from cassava, stuck starch, and other cassava residue. Spray these with hot water to rinse off greasy soapy water (containing residue) from surfaces.

Roasting/frying pans

- Scrub the inside of the roasting pans with soap and water. Clean dry with a napkin. Grease with vegetable oil.

Walls, floors, windows, and roofs

- Clean roof girders and collect dust with appropriate vacuum cleaning attachments (or other alternative means).
- Clean doors, windows, and window screens with clean water or vacuum cleaning.

- Mechanically scrub and clean walls and floors with detergent solution, then rinse and dry.
- Hose away all dirt down drains—especially for the wet processing areas—using high-pressure jets for relatively inaccessible spots.
- Dry smooth floors with rubber squeegees pressing them in close contact with the floor by pressure on the handle and pushing along the floor.
- Vacuum clean floors of warehouses and storage rooms to remove dust or spilled, dried materials.

Management and control of rodents, insects, reptiles, and domestic animals

- Install rodent traps with baits at strategic areas in the processing area and along known rodent pathways.
- Seal and fill all cracks and holes observed.
- Containers for storing food must be rodent proof.
- Employ if necessary anticoagulant rodenticides to kill rodents.
- Regularly spray environment with insecticides (NB: Insecticides must not be used on production floor during production and must not be sprayed directly over food contact surfaces and equipment surfaces in direct contact with food).
- Install net screens on doors and windows to keep away insects.
- Check dark cabinets and drawers regularly for eggs of cockroaches and thoroughly clean and spray with insecticides.
- Cover fermentation troughs containing fermenting cassava mash with net screens to keep away houseflies and fruit flies.
- Cover ventilation openings on buildings with net screens.

Waste management

- Install appropriate waste management systems for both solid and liquid waste.
- Construct a soak away pit for managing all liquid waste and washing waters and channel all drains from the processing area into the soak away.
- Use peel for animal feed for generation of biogas, which can be used for roasting or frying *gari*.

Plant layout and design

- Arrange all equipment and facilities such that operational processes can flow smoothly (see Figure 2).
- Avoid as much as possible interruptions in the sequence of flow of raw material (roots) and intermediate products during processing from the reception of raw cassava, peeling, washing, grating, and de-watering, and roasting to packaging and storage.
- Ensure ample space in processing area for movement of workers and for prevention of microbial or physical cross-contamination of online or final products, and prevention of personal injury.
- Allow reasonable distance between the wet (peeling, grating, dewatering pressing) and dry (drying, milling, packaging etc.) sections.
- Ensure adequate drainage system within and outside the plant.
- Locate toilets far away from the processing, drying, and storage areas.

V

Quality and Management System Certification

Purpose

The standards bureau of each country has a statutory mandate to test all products manufactured internally and imported goods for conformity to the approved national standards. The product testing is done in the specialized laboratories for each product.

Gari samples will be tested in food related laboratories, which may include chemical and microbiology laboratories. The laboratories provide test services, advice, information and sometimes training to *gari* processors and importers to ensure that contaminated and/or adulterated *gari* is not sold in the market. *Gari* is tested for micro-organisms of public health importance, chemical contaminants (e.g., pesticide residue and heavy metals), residual toxins (cyanogens, mycotoxins) and physical characteristics (e.g. color and particle size) as listed in Form 3. The tests help to assure the quality and safety of *gari* for the benefit of the consumer, producer, and importer. *Gari* samples may be submitted by the processor or prospective importer for testing and may be collected by the surveillance inspector from the processors or from the marketers.

Quality inspection and certification (standard mark)

All bureaux of standards have standards marks, which manufacturers of certified, good-quality items are permited to affix on the packages of their goods as an assurance to the customers that the product conforms to approved quality standards. The quality mark increases consumer confidence and the marketability of the item. Consumers are readily willing to pay more for *gari* with a quality mark compared with *gari* without a quality mark.

A *gari* processor may apply to the Bureau of Standards for certification. The bureau's quality experts will audit the quality of the *gari* and quality control procedure used by the processor. The process involves visits of the experts to the processing plant. The raw materials, production processes, finished *gari*, quality assurance facilities, quality monitoring instruments, and records will be evaluated. The hygiene conditions under which the *gari* is produced will be tested. The records of Good manufacturing practices (GMPs) and HACCP being implemented to prevent contamination and ensure the production of safe *gari* will be inspected. *Gari* samples will be collected and tested in the laboratory. The processor may be granted approval to use the Quality Mark if the laboratory test show that the *gari* meets the approved standards. The processor will be required to maintain continuous compliance to the approved (or any revised) standard as long as the *gari* is marketed. The sample of *gari* could be collected at any time, by the bureau experts, directly from the market for laboratory testing without notification to the processor. Failure of the *gari* samples to conform to standard may lead to withdrawal of the Standard Mark permit from the processor.

Conformity assessment

Some countries implement conformity assessment of goods before they are allowed into the country. The purpose is to ensure that the item does not pose a public health risk to consumers. A *gari* processor intending to export *gari* to a country where conformity assessment is required will be expected to send the *gari* sample for assessment prior shipping.

Environmental management system (EMS)

According to Dziedzoave et al. 2006, cassava peel, waste water from cassava processing operations, and other processing tools constitute health hazards in the processing environment. Studies of environmental impact of cassava processing units in DR Congo showed that cassava processing plants that did not have any environmental management system (EMS) in place generate effluent with high organic and inorganic matter. The concentrations of cyanogens, and organic matter measured as biological oxygen demand (BOD) or chemical oxygen demand (COD), were higher than the tolerable levels in water. Cassava processing into gari and other products produces different types of waste. This waste includes high fiber and cyanogens containing peel (at least 20% of the cassava roots); organic matter, soil, effluent with high levels of cyanogens from the grating washing and de-watering operations. These environmental contaminants cause high BOD, high COD, and high concentrations of toxic cyanogens in waterways. High BOD value for sewage produced by a cassava processing plant suggests that the waste water is highly polluted, and the amount of dissolved oxygen needed by aerobic biological organisms to decompose the organic material (waste) is high. Similarly, bacteria will be involved in the breakdown of the organic matter, phosphates, nitrites, etc., and will use up oxygen for the activity. As a result, there is lower amount of dissolved oxygen available for other aquatic organisms and animals, such as fishe, to live. Similarly, high COD indicates high level of organic chemicals present in the effluent, causing threats to plant and animal life (flora and fauna) if the sewage is discharged into river bodies, and downstream. Effluent from gari processing plants, if untreated, could kill plants along their path, cause a foul odor, and possibly contaminate ground water. The chemicals could invariably be carcinogenic if the water is used by humans. Such environmental effects are becoming recognized as public health risks and in some places schemes are necessary or mandatory to reduce the impact. Processing plants producing effluent with BOD and COD above tolerable limits are therefore required to treat the effluent before discharging it into nearby rivers. Such schemes will increasingly be demanded from cassava processors (including gari processors) by their neighboring communities, governments, regulatory agencies, trade associations, customers, nongovernmental organizations (NGOs), academia, and neighbours of the processing plants.

The Environmental management system (EMS) can be used by processors to control negative impacts, improve the environment, and maintain profitability at the same time. Standards bureaux and other private companies specializing in environmental management can help gari processors in designing EMS to ameliorate any negative impact. Providing help in the form of waste treatment technology, cost-effective environmentally friendly practices, and training to gari processors should be the priority of standards bureaux, food regulatory agencies, and all other environmental protection agencies rather than penalizing gari processors who may not have the knowledge or techniques for treating their waste. Partnership between standards bureaux and other public and private agencies towards better management of the environment is required to maintain a safe environment and prevent public health disasters. Adopting environmentally friendly practices will increase the image and access of gari processors to new consumers and business partners.

Certification of management system to international standards

As already demonstrated in Chapters 2 and 3, it is important for *gari* processors to develop and thoroughly implement management systems (Hazard analysis and critical control point or HACCP, Quality management system, Safety management system, Environmental management system, and others) to conform to international standards. Once the management systems are operational, it is equally important for the *gari* processor that wishes to increase market access in the global market to seek for certification of its management system based on international standards. Certification of management systems helps the processor to guarantee long-term effectiveness of the operation and to continuously benefit from the production enterprise. Similar to the procedure for obtaining a Standards Mark for *gari*, certification of the management systems can be carried out by the relevant bureau of standard experts who will visit the processing plant to assess the management system being adopted by the processor. A Certification Mark may be issued to the *gari* processor if the management systems being implemented are found to be adequate when audited against the international standards. The certification shows that the processor uses industry best practices and is able to maintain good quality and safety of the *gari* sold in the international market. Further surveillance will be done by the bureau to assess whether the processor continues to conform and still working to the best practice specifications laid out in the standard or management scheme and annual renewal of certification will be required by the processor. The Management Systems Certification Mark can be used for advertisement and promotion of the *gari* (on letter heads, brochures, etc) but cannot be placed on the *gari* package since it is not the *gari* that is certified but the system used to achieve high quality and safety of the *gari* (http://www.unbs.go.ug/main.php?menuid=50).

VI
Conclusion

Gari processors who apply Hazard analysis critical control points (HACCP) quality management principles, and good manufacturing and hygienic practices (GMP and GHP) in producing *gari* will be able to make *gari* that complies with both national and international safety and quality standards. The procedures explained for obtaining quality certification and registering the management practices used in the production process for *gari* should be of help to *gari* processors who aspire to increase profitability. By obtaining a standard mark, a conformity certificate, or Management Systems Certification Mark, a processor is certain to increase the enterprise's competitive advantage in the market through improved operational efficiency or effectiveness thereby reducing production costs. In addition, customer satisfaction can be increased, trade barriers removed, and brand name and company reputation improved. The *gari* processor will be able to meet the planned mission or business targets without endangering the health of the population eating the products or those around the processing plant.

Appendices

Appendix 1. Sierra Leone Standard for *gari*

SIERRA LEONE STANDARD *SLS 8: 2010*

Roots and Tubers – Specification for Gari

1.0 **Scope**

This Sierra Leone Standard specifies the requirements, methods of sampling and test for *gari*.

2.0 **Normative references**

The following references contain provisions applicable to this Sierra Leone Standard. At the time of publication, the editions indicated were valid.

All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

2.1 SLS 4: 2010 General Standard for the labelling of pre-packaged foods.

2.2 SLS 2: 2010 General Principles of Food Hygiene.

3.0 **Definitions**

For the purposes of this Sierra Leone Standard the following definitions apply.

3.1 ***Gari***: a dry granular pregelled particulate product obtained by artisanal or industrial processing of cassava roots (*Manihot esculenta* Crantz). The processing consist of peeling, washing and grating of the roots, followed by fermentation, and de-watering, fragmentation, sifting and roasting to dryness by stirring.

3.2 **Foreign matter:** foreign matter is all unapproved matter other than *gari* granules.

3.3 **Alteration:** alteration of the composition of *gari* so that the physical and chemical quality of the product is adversely affected.

3.4 **Food additives:** any substance which is not normally consumed as foodstuff but which is intentionally added to a foodstuff for a technological (including sensory) purpose and which is present in the final product. The term does not include substances added for the purpose of improving nutritional values.

3.5 **Enrichment:** make richer in quality and nutritive value of food.

3.6 **Fortify:** increase the nutritive value of food.

4.0 Requirements

4.1 **Particle size:** *Gari* shall be of uniform particle size as much as possible and about 80% of the particle should range between 0.25 mm to 2.0 mm. On visual examination, *Gari* may be described as extra fine, fine, medium or coarse.

4.1.1 **Extra fine *gari*:** Extra fine *gari* shall be of particle size 0.25 mm to 0.5 mm. 100% by weight shall easily pass through a sieve of 0.5 mm aperture size but of which not less than 40% by weight shall easily pass through sieve of 0.25 mm aperture size.

4.1.2 **Fine *gari*:** Fine *gari* shall be of particle size 0.5 mm to 1 mm. 100% by weight shall easily pass through a sieve of 1 mm aperture size but of which not less than 40% by weight shall easily pass through sieve of 0.5 mm aperture size.

4.1.3 **Medium size:** Medium size *gari* shall be of particle size 1 mm to 1.25 mm. 100% by weight shall easily pass through a sieve of 1.25 mm aperture size but of which not less than 40% by weight shall easily pass through sieve of 1 mm aperture size.

4.1.4 **Coarse *gari*:** Coarse *gari* shall be of particle size of 1.25 mm to 2.0 mm. 100% by weight shall easily pass through a sieve of 2.0 mm aperture size but of which not less than 40% by weight shall easily pass through sieve of 1.25 mm aperture size.

Note: Particle size below 0.25 mm shall be considered dust and those above 2.0 mm shall be considered as lumps.

4.1.5 Unclassified *gari*:This is *gari*, which has not been classified by the sieve method.

Table 1. Chemical requirement for *Gari*

Parameter	Maximum Limit
Moisture content (% m/m) max	12
Total acidity (% m/m) as lactic acid	0.6 –1.0
Cyanogenic glycosides and hydrocyanic acid (mg/kg) max	2.0
Crude fibre (% m/m) max	2.0
Acid insoluble ash (%m/m) max.	0.1

5.0 **Other requirements**

5.1 **Raw materials:** *Gari* shall be prepared from clean cassava roots in good physiological condition.

5.2 **Adulteration:** *Gari* shall not be adulterated by any means whatsoever.

5.3 **Organoleptic properties:** The colour, taste and odour of *gari* shall be characteristic of the product and shall be free from objectionable matter.

5.4 **Foreign matter:** *Gari* shall be practically free of foreign matter.

5.5 **Optional ingredients:** *Gari* may contain one or more of the following ingredients in amounts agreed to between the customer and the supplier.

(a) edible fats or oils
(b) edible common salt.

5.5 **Enrichment/fortification (optional):** The addition of vitamins, proteins, and other nutrients may be added.

5.7 **Food additives:** No food additive shall be added to *gari*.

5.8 **Microbiological status:** *Gari* shall also comply with the microbiological requirements laid down in Table 2.

5.9 **Contaminants**

5.9.1 **Heavy metals:** *Gari* shall not contain heavy metals in amounts that may represent a hazard to human health and shall not exceed the limits specified in Table 3.

Table 2. Microbiological requirements for *gari*

Parameter	Maximum limit (cfu/g)
Total bacteria count	1.0×10^4
Staphylococcus aureus	1.0×10^2
Clostridium perfringens	1.0×10^2
Yeast and mould (cfu/g)	1.0×10^4
Salmonella	NIL
Fecal coliforms	NIL

Table 3. Heavy metals

Heavy metal	Maximum limit (mg/kg)
Lead (Pb)	0,1
Arsenic (As)	0

5.9.2 **Pesticide residues:** *Gari* shall be prepared with special care under good manufacturing practices, so that residues of those pesticides which may be required in the production, storage, or processing of the cassava or *gari* or of the premises and equipment used for processing, shall not exceed the limits prescribed in Table 4.

5.10 **Hygiene:** It is recommended that the product covered by the provisions of this standard be prepared and handled in accordance with good manufacturing practices.

6. **Labeling:** In addition to the provisions of SLS 4 General Standard for the Labelling of prepackaged foods, the following specific provisions apply.

Table 4. Limits for Pesticides and other chemical residues*

Residue	Limit (mg/kg)
Etrimphos, Dichlorvos, Bioresmethrin or Methoprene	5.0
Bromophos, Chlorpyriphos methyl , Fenitrothion or Pirimiphos methyl	10.0
Pyrethrins	3.0
Deltamethrin	1.0
Permethrin, Phenothrin or Fenvalerate	2.0
Piperonyl butoxide	20.0
[2]Methyl Bromide	50.0
Phosphine	0.1
Malathion	8.0
[3]PCBs as Aroclor 1254	10.0

6.1 **Name of product:** The name of the product to be shown on the label shall be *gari*. The name may show particle size in accordance with the description contained in section 4.1 of this specification.

6.1.1 Where ingredients have been added in accordance with section 5 of this standard, the label shall indicate in close proximity with the name of the product that the product has been enriched/fortified and the ingredient or ingredients used for the enrichment/fortification shall be listed.

a) The origin of added fats and oils shall be declared.
b) Storage conditions—a cool, dry environment.
c) Manufacturing and best before date
d) Name and address of manufacturer.
e) Batch number or code

7.0 Packaging, transportation and storage

7.1 *Gari* shall be packaged, transported or stored in containers which will safeguard the hygienic, nutritional, and organoleptic qualities of the product.

7.2 The packaging material shall be such as will protect the product against bacteriological and other contamination. It shall protect the product as far as possible against any absorption of moisture and odor and against leakage. The packaging shall not impart any odor, taste or color or any other extraneous property to the product and should not result in contamination of the product with substances of which the packaging material is made.

8.0 Testing

Tests shall be carried out as prescribed in the methods specified in Annex A.

9.0 Criteria for conformity

A lot shall be declared as conforming to this standard if the final sample satisfies all the requirements given in this specification - SLS 8.

Appendix 2.
Picrate scoring color chart (Bainbridge et al. 1996)

9 8 7 6 5 4 3 2 1

References

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