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Quality Management Manual for

Production of high quality Cassava flour

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International Institute of Tropical Agriculture – Institut international d'agriculture tropicale – www.iita.org

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FOREWORD

There has been an increasing interest in the safety and quality of cassava products, including cyanogenic potential and aflatoxin contamination. In several African countries cassava is grown and consumed as a staple food. Significant advances have been made in processing the cassava root into products for urban consumers as well as industrial end-users; and African governments are beginning to recognize the potential of cassava as a food security crop, an industrial commodity and a raw material for the production of various exportable and import substitution products. Over the years, new cassava varieties, food habits and industrial applications have evolved leading to preferences that in turn influence consumer acceptability, market value and market opportunities. Safety and Quality are central to the challenges posed by these developments and much has been done in this respect through the efforts of various national and international research and regulatory institutions, notably, the International Institute of Tropical Agriculture (IITA) in Nigeria, The Food Research Institute in Ghana, the National Standards Bodies of Ghana, Nigeria, Madagascar, Tanzania and Zambia amongst others.

Safety and quality assurance of food products are paramount aspects of food production and processing possible through implementation of adequately defined management systems, which address health hazards at all the steps along the food chain. It is therefore timely and relevant to the development and promotion of the cassava industry in Africa that this quality management manual has been developed. High Quality Cassava Flour (HQCF), is currently the most promising industrial cassava product after cassava starch and chips, and thus rightly constitutes the focus of the manual. The book presents technical information on the production and quality management of HQCF in a systematic way that makes interesting reading. It is sufficiently detailed in content, yet presented in a style simple enough to facilitate easy understanding. The highlight of the book is the presentation of the Quality/Hazard Analysis Critical Control

Point System for HQCF production in a systematic tabular format that enhances ease of application of the system by any entrepreneur who is committed to quality management.

Even though primarily intended for entrepreneurs involved in cassava processing, the concepts and guidelines outlined, provide valuable reference for students of Food Science Biochemistry and Agriculture, research scientists, quality advocates, extension workers and other relevant development workers, who would find very useful applications for these concepts in their respective fields of operation. This manual will be found useful by regulatory agencies in cassava processing countries for setting effective and achievable quality and safety standards for high quality cassava flour.

I expect that the knowledge provided herein would sensitize all stakeholders within the cassava industry – namely, entrepreneurs, end-users, researchers, funding agencies and financial institutions, policy makers, non-governmental organizations, government agencies, marketing companies, farmers, and most especially processors – to pursue quality with all the diligence that is required to increase consumer acceptability and market value; and the positive results from the application of the concepts to stimulate policy makers, in African countries especially, to develop policies that can further enhance market opportunities for cassava SMEs.

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ACKNOWLEDGEMENT

The authors are very grateful to the Common Fund for Commodities (CFC) for funding the publishing of this manual; the UK Department For International Development (DFID); and the Crop Post-Harvest Program of the Natural Resources International, for the funding provided to facilitate the collection of the data that went into the preparation of this manual. Many thanks also go to the Food Research Institute, Ghana, the International Institute for Tropical Agriculture (IITA), and the Integrated Productivity Development Center (INPRODEC), Ghana, for releasing their staff to assist in the production of this manual. It is hoped that this quality manual will guide the operations of small- medium-scale enterprises (SMEs) involved in the production of high quality cassava flour for the domestic and international markets.

EXECUTIVE SUMMARY

The high quality cassava flour (HQCF) industry has just started to evolve in Africa and elsewhere. The sustainability of the growing industry, the profitability of small- and medium-scale enterprises (SMEs) that are active in the industry and the good-health of consumers can best be guaranteed through the adoption of proper quality and food safety procedures. Cassava processing enterprises involved in the production of HQCF must therefore be committed to the quality and food safety of the HQCF. They must also have the right technology, appropriate processing machinery, standard testing instruments and the necessary technical expertise. This quality manual was therefore developed to guide small- to medium-scale cassava processors in the design and implementation of Hazard Analysis Critical Control Point (HACCP) system and Good Manufacturing Practices (GMP) plans for HQCF production. It describes the HQCF production methods, and explains in practical terms the concept of HACCP/QACCP quality system and procedure for application to HQCF production. The procedures described in this manual should help cassava processing enterprises to implement the HACCP/QACCP system from the point of root delivery through every processing operation to marketing of high quality cassava flour ensuring that the microbiological, physical and chemical standards of the product are met. It is expected that the use of this manual will facilitate the development of the cassava processing sub-sector, assist in making HQCF meet the quality and safety limits of all categories of end users and make HQCF compete favorably with imported products. It will also aid regulatory agencies in different cassava-growing countries to set achievable quality objectives for HQCF.

TERMS, ABBREVIATIONS AND DEFINITIONS

For the purposes of this quality manual, the following expressions or words are defined according to the codex alimentarius commission recommended code of practice CAC/RCP IB for general hygiene requirements for food:

Cleaning The removal of soil, food residues, dirt, dust, grease or other objectionable matter.

CNP Cyanogenic potential (CNP) of cassava (roots, leaves, stem) or of any cassava product is the quantity of hydrogen cyanide it can possible release during processing, storage, marketing or after consumption.

Container Any enclosure for food, including but not limited to metal, plastic, or polypropylene sacs and polyethylene.

Contaminant Any biological, chemical or physical agent, foreign matter or other substances not intentionally added to HQCF which may compromise safety.

Contamination The introduction or occurrence of a contaminant in food environment.

Food Hygiene All conditions and measures necessary to ensure the safety and suitability of food (HQCF) at all stages of the food chain.

Hazard A biological (e.g. pathogens, toxins), chemical (e.g. pesticides, heavy metals) or physical (e.g. metal fragments, stones) agent in a food material or a condition of food (HQCF) with potential to cause an adverse health effect.

HACCP Hazard Analysis and Critical Control Point: A system, which identifies, evaluates and controls hazards, which are significant for food safety.

QACCP	Quality Analysis and Critical Control Point: A system, which identifies, evaluates and controls hazards as well as potential quality defects which are significant for food quality and safety.
Food Handler	Any person who directly handles food, food equipment and utensils or food contacts surfaces and is therefore expected to comply with food hygiene requirements.
Food Safety	Assurance that food (HQCF) will not cause harm to consumer when it is prepared or eaten according to its intended use.
Food Suitability	Assurance that food is acceptable for human consumption according to its intended use.
Control (verb)	To take all necessary action to ensure and maintain compliance with criteria established in the HACCP/QACCP plan.
Control (noun)	The state wherein correct procedures are being followed and criteria are being met.
Control Measure(s)	Any action(s) and activity(ies) that can be used to prevent or eliminate a food safety hazard/quality defect or reduce it to an acceptable level.
Corrective Action	Any action to be taken when the results of monitoring at the critical control point (CCP), indicates loss of control.
CCP	Critical control point is a step at which control can be applied and is essential to prevent or eliminate a food safety hazard/quality defect or reduce it to an acceptable level.
Critical Limit	A criterion which separates acceptability from unacceptability.

Deviation	Failure to meet a critical limit.
Flow Diagram	A systematic representation of the sequence of steps or operations used in the production of a particular food item.
Step	A point or procedure, unit operation or stage in the food chain from raw material to finished product.
HACCP/QACCP Plan	A document prepared in accordance with the principles of HACCP/QACCP to ensure control of hazards/quality defects, which are significant for food safety and quality in the segment of the food chain under consideration.
Hazard Analysis	The process of collecting and evaluating information on hazard/quality defects and conditions leading to their occurrence to decide which are significant for food safety and therefore should be addressed in the HACCP/QACCP plan.
Monitor	The art of conducting a planned sequence of observation or measurement of control parameters to assess whether a CCP is under control or not.
Validation	Obtaining evidences that the elements of the HACCP/QACCP plan are effective.
Verification	The application of methods, procedures, tests and other evaluations in addition to monitoring to determine compliance with the HACCP/QACCP plan.

INTRODUCTION

The purpose of eating food is to supply nutrients to the body for the performance of several body functions. Food provides both energy and the materials needed to build and maintain all body cells and is composed of carbohydrates, proteins, fats and their derivatives. In addition to these, there is a group of inorganic mineral components and a diverse group of organic substances present in comparatively small proportions and these include vitamins, enzymes, emulsifiers, acids, oxidants, antioxidants, pigments, and flavors. Food also contains water which is a very important component acting as a solvent and lubricant, as a medium for transporting nutrients and waste, and as a medium for temperature regulation. Carbohydrates provide the major source of fuel for the body. Lipids (mostly fats and oils) are a key energy source for the body and the major form for energy storage in the body. Proteins are the main structural building blocks of the body and constitute a major part of bone and muscle; they are also important components of blood, cell membrane, and the immune system. The main function of vitamins is to enable many chemical reactions in the body to occur. Some of these reactions help release the energy trapped in carbohydrates, lipids, and proteins. Minerals are critical players in the functioning of the nervous system, metabolic processes, water balance, and structural systems. Consumers consider food products that contain adequate amounts of these food components to be of good quality. Therefore It should be the desire of every food manufacturer to produce food products which are of good quality.

Since we live in a competitive world, a food manufacturer or entrepreneur must aim to produce a product which consumers will prefer to that of the competitors and the way to achieve this is to adhere to processing procedures that will ensure highest quality. Consumers also like to know or have an idea as to what they are always buying, so it is important that a food manufacturer consistently produces food of a certain quality, and there must not be differences in the food product that the consumers buy from the manufacturer on different days. Food manufacturers therefore develop a quality assurance or a systematic approach to food processing that regularly and consistently produce a food product of a certain quality. Of even more basic importance is the safety of the food which is purchased and eaten by the consumers.

Over the years, different systems or approaches have been developed by food manufactures to ensure that they produce safe foods and this combined with the

desire to produce foods of high quality will to a large extent determine the success of the food producer in a competitive environment. Governments have a duty to protect the health of their citizens, therefore they set up regulatory agencies which develop and enforce standards for various food products to guarantee the safety and quality of foods produced and sold on the markets.

In most parts of Africa, processed foods are produced both in the formal and informal sectors of the economy. Many well established food factories produce processed foods using modern methods of food technology. However a bulk of the foods may be produced by traditional processors who use simpler or less sophisticated technologies and equipment. Very often the activities of the food factories are supervised by the regulatory agencies but production by traditional food processors may not come under the strict supervision of these agencies. In recent times a lot of the products produced by the traditional processors have been up-scaled and up-graded by Small- and Medium-scale Enterprises (SMEs) who use mechanized and semi-mechanized operations to produce the indigenous foods formerly produced almost entirely by the traditional processors. Also new products such as convenience foods are being developed but are produced by the SMEs. It is important that quality systems are developed and implemented by the SMEs and traditional processors to ensure safety and quality of their food products in the same manner as the modern food factories. Implementation of such quality systems by the SMEs and traditional processors will improve the competitiveness of their products and in the long term give them access to foreign markets.

Cassava plays a vital role in the food security of the rural economies of sub-Saharan African countries because of its resilience to several biotic and abiotic stresses such as diseases, flood, drought, and low soil fertility. Besides it serves as the basis for development of small industries providing jobs and wealth in the rural communities. Cassava performs different roles for different people in Africa. It serves as a famine reserve crop, a rural food staple, a convenience food for urban dwellers, an industrial raw material, a cash crop, and a foreign exchange earner. 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 earning. To achieve this, efforts in increasing cassava production are being made simultaneously with increasing value addition, market diversification and trade in high-value and shelf-stable cassava products such as high quality cassava flour (HQCF), cassava starch and dried cassava chips.

High quality cassava flour has been found to be suitable for several applications at household level, for making a variety of pastries and convenience foods at urban centers and as an acceptable raw material for the manufacture of industrial items such as textile, plywood, paper, packaged foods, etc. 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, and improve farmers' earnings and their livelihoods.

Commercial production of HQCF is relatively new in Africa and the technology is still being used mainly by small- and medium-scale processors. Most of the small-scale processors have difficulties in production during the rainy season, meeting the quantity, quality and regularity of supply required by the industrial users because the technology has not been perfected yet. In addition, small-scale processors have found it difficult to meet the safety standards set for cassava products by the national and international regulatory agencies regarding microbial load and cyanogen. This limits their access to national as well as international or export markets. The absence of quality management systems constitutes additional impediment to resolving these quality and safety challenges. However, mycotoxin is not expected to be of significant hazard if the HQCF is produced efficiently.

The International Institute of Tropical Agriculture (IITA) and the Food Research Institute (FRI) have in the past been involved in investigating the determinants of quality for HQCF by testing the technology with many national food and agricultural institutions, farmers and end-users in many parts of Africa, such as Nigeria, Ghana, Madagascar, Tanzania and Zambia. The results of these investigations have helped in the set up of the quality and safety programs explained in this manual.

This manual lays the foundation for entrepreneurs to implement quality systems; and spells out hygienic practices for the preparation, processing, packaging, storage, transportation and distribution of HQCF in order to protect the health of consumers and enhance the competitive market edge of SMEs processing high quality cassava flour. This manual contains illustrations of the HQCF production methods, and the procedure for application of HACCP/QACCP to HQCF production through the integration of HACCP/QACCP system with other quality programs to offer a logical approach to the control of microbiological, chemical and physical hazards as well as quality defects associated with HQCF processing from the point of root delivery through every unit operation of the process.

Since HACCP/QACCP system is plant specific, the proposed quality management system must be appropriately modified to suit the specific operations of each SME that apply the concept. A gap analysis, taking into account the prevailing conditions that have the capacity of rendering the implementation of the proposed concept and guidelines ineffective should be undertaken.

The guidelines should help in ensuring GMP during the production of HQCF as well as promote the safety and quality of HQCF through the implementation of food safety systems such as HACCP/QACCP at the SME level. It is expected that this will lead to production of microbiologically safe HQCF of consistent quality, improvement in the image of cassava and ensuring its perfect integration into industry, particularly the food sector.

PART I

BACKGROUND INFORMATION ON HIGH QUALITY CASSAVA FLOUR AND QUALITY MANAGEMENT SYSTEMS

2006

1.1 CASSAVA AND CASSAVA PROCESSING

Cassava has become an increasingly important crop in many tropical and semi-tropical countries especially in Africa. This is because it is a high yielding durable plant which is able to grow under a variety of climatic and soil conditions including low fertility and high acidity. Cassava is drought-tolerant and is able to grow on poor and marginal soils on which other crops are unable to survive. It is relatively easy to produce. Once the crop is established, it has no critical period when lack of rain will cause crop failure. It is high yielding, giving high return of food per unit of energy input. Its harvesting is flexible because it can be staggered for up to three years. It is therefore sometimes referred to as an excellent famine reserve crop.

Cassava roots have high starch content, about 60%, and it is therefore a cheap and excellent source of dietary carbohydrate. Although, the roots are rich in calcium, thiamine, riboflavin and niacin, they nevertheless contain low levels of protein which can only be improved by incorporating high protein containing crops such as cowpeas, and soybeans in cassava diets as a means of protein fortification. Fortunately, cassava leaves contain about 7% protein, are also rich in minerals, vitamins and all essential amino acids except methionine and phenylalanine. The cassava leaves are therefore used as protein sources for cassava roots diets in many parts of Africa.

Cassava roots have a short storage life and begin to deteriorate only 2 to 3 days after uprooting. Unfortunately apart from leaving the mature roots of cassava unharvested in the ground till they are needed, there are no commercial methods for storage of cassava roots for long periods of time. Storage of cassava roots underground ties up useful land, the roots over-mature, and they become more fibrous and even woody. Processing still appears to be the best method of preserving the highly perishable cassava roots and for removing cyanogenic glucosides (linamarin and lotaustralin) which impart toxicity to the roots. Cassava processing methods involving different combinations of drying, grating, soaking, boiling and fermentation of whole or fragmented roots reduce the total cyanide content of cassava products. Cassava roots contain endogenous enzyme linamarase, which in contact with cyanogenic glucosides, breaks down the glucosides into forms which are readily removed from the meal. In undamaged roots, the linamarase enzyme and cyanogenic glucosides are kept apart in the intact cells. Whilst the linamarase enzyme is in the cell membrane, the cyanogenic glucosides are found in the vacuoles of the cells. During processing operations,

particularly grating, the cassava tissues are disrupted, the linamarase enzyme make contact with the cyanogenic glucosides and breaks them down into acetone cyanohydrins and glucose. The acetone cyanohydrins, apart from being soluble in water, further decompose into hydrogen cyanide and acetone. Both are soluble in water while the hydrogen cyanide is also volatile. These compounds are therefore removed from the cassava meal during dewatering, drying, heating, etc. to produce very safe food, feed and industrial raw materials such as HQCF, starch, chips, gari, etc. The extent of detoxification that occurs depends on the adequacy of the processing operations. Proper processing leads to production of safe food products and raw materials and this increases the market opportunities for farmers, motivates them to produce more cassava, and can provide opportunities for self-reliance in supply of food, feed and industrial raw material.

1.2 DESCRIPTION AND PRODUCTION OF HIGH QUALITY CASSAVA FLOUR

Traditionally cassava flours have been produced and used for food preparation in most African countries where cassava is cultivated. Variations exist in the methods used for the production of traditional cassava flour but in every instance the cassava product undergoes an extent of fermentation. In communities where high cyanogenic potential (CNP) cassava varieties (CNP> 100mg/kg HCN_{eq}) are cultivated and processed into flour, the peeled or unpeeled roots are soaked in water (submerged fermentation) for a number of days to ferment, soften and detoxify before they are partially dewatered, dried and milled into flour. In communities where low CNP cassava varieties (CNP < 100mg/kg HCN_{eq}) are used, cassava flour is simply made by slicing or chipping the peeled roots and drying them in the sun. In the production of the traditional flours (*makopa* in Eastern and Southern Africa, *lafun, fufu and kokonte* in West Africa), fermentation of the product continues during the often prolonged sun-drying. The final flour is prepared at the domestic level, as a soft pudding by cooking. This destroys substantial amounts of micro-organisms of public health concern in the flour before consumption. However, the presence of micro-organisms in the flour, the low pH and the acidity imparted to the traditional flour during fermentation make the flour unsuitable for most processes to which industrial end-users such as bread, noodles, biscuits, wafers, pastry, and textile manufacturers can put the flour. High quality cassava flour (HQCF) which has been produced without allowing extensive fermentation to occur is more preferred.

HQCF is not expected to be contaminated with mycotoxin if it is produced efficiently as explained in this manual. This is because extensive mould growth can not occur if the product is dried within the specified period to moisture content of less than 10% and stored properly. However some mycotoxin detected in fermented cassava chips (kokonte) includes Stergmatocyatin, patulin, cyclopiazonic acid, penicillic acid and tenuazonic acid (Wareing, 2001).

HQCF is defined as fine flour produced from wholesome freshly harvested and rapidly processed cassava roots. The flow chart for the production of HQCF, based on the method developed by IITA (Onabolu *et al.*, 1998) and tested in Nigeria, Ghana, Madagascar, Tanzania and Zambia is shown in Fig. 1. The full description of the unit operations is presented in Appendix I. Roots are peeled, washed and grated, followed by adequate dewatering and immediate drying prior to milling/grinding and sieving. This method can be used for processing high or low CNP cassava varieties. Only white, creamy or orange flesh cassava roots or parts of it should be used. The taste and odor of HQCF 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.

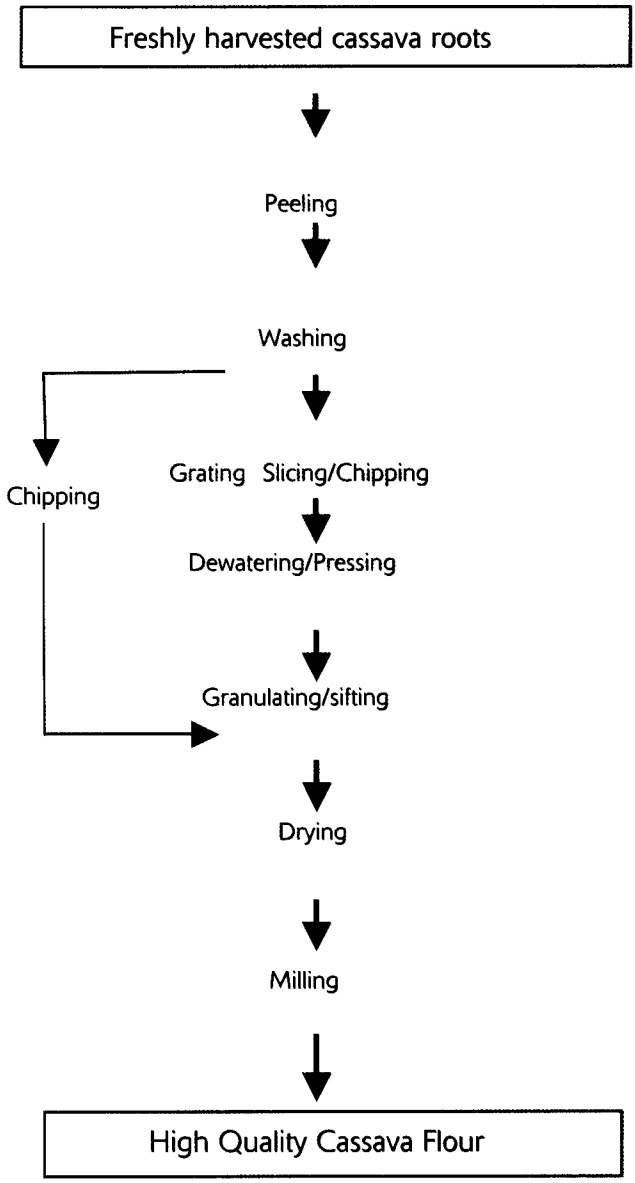


Figure1. **Flow diagram for high quality cassava flour production**

HQCF can also be produced from freshly harvested cassava roots of low cyanide varieties (CNP<100mg/kg HCN_{eq}) by peeling followed by washing, chipping, drying, milling, and sieving. This method must not be used to make HQCF from high CNP varieties (CNP>100mg/kg HCN_{eq}) if the flour is meant for manufacture of human food products or for direct human consumption. Chipping of high CNP cassava varieties followed by immediate drying constitutes "inadequate

processing" in which insufficient removal of cyanogens may occur. Such flour is not fit for human consumption but may be used for non-food purposes such as manufacture of plywood, textile, paper, etc. Such cassava flour must be labeled "not for food"; and its use in the industry controlled in order not to give rise to health risks for the employees due to release of HCN in the work environment.

Processing of cassava into high quality cassava flour is important in extending the shelf life of cassava and reducing content of the cyanogenic glucosides to safe limits. Although, due to the nature of the technology adopted and the machinery used, SMEs involved in the processing of HQCF face difficult challenges in achieving the required quality and safety of cassava flour. However, efforts must be made to produce HQCF under hygienic sanitary conditions free from significant public health hazards. High quality and safer cassava flour will ensure consumer confidence in the product.

It is important for operators or intending investors in small- and medium-scale cassava processing enterprises to satisfy the national quality standards or food laws set by the Standards Bureau of the country as well as the regional and global trade standards, most of which are based on ISO 9000 and the standards set by the Codex Alimentarius Commission of the United Nations.

1.3 INTENDED USE OF HQCF

The unfermented HQCF is useful in the convenience or fast food industry for making a variety of pastries at 100% use or as a composite of wheat flour particularly for bread baking (20% composite with wheat). It is very acceptable as raw material in the food and beverage industry for the manufacture of biscuits, noodles, baby foods, alcoholic drinks, etc; and as binding or thickening agent in soups and stews.

High quality cassava flour is also an acceptable raw material in various industries:

- manufacture of gum,
- extender for plywood glues,
- manufacture of paperboard adhesives,
- glucose syrup and alcohol production,
- sizing in textile manufacture.

The most important, in terms of potential sustainable growth market is its use for the manufacture of high-grade foods (baby food, biscuit, noodles, meat sausages, bread, etc).

Table 1. **Recommended inclusion levels of HQCF in different cassava-based products**

Group of end-users	Product/end-use	Inclusion levels
in composite with wheat flour		
Bread Bakers	Bread including French bread (Baguette)	20% (Optimum)
Food factories	Biscuits	10-50%
	Wafers	10 %
	Noodles	10 %
Home Caterers	Cakes	100 %
	Chinchin	25-100 %
	Meat/fish pie	10-100 %
	Buns, Fish rolls	10-12.5 %
	Puff-puff etc	10-25 %
Restaurants	Stiff porridge (Cassava-Maize Semo/ Ugali)	10-18 %
Others: as adhesive base in composite with native starch		
Industrial Non-food Factories	Paper	0-96%
	Matches (starch residue is preferred)	50%
	Textile	20-50%
	Extender in Plywood Manufacture	30 – 100%

Abass *et al.,* 1998; Graffham et al., 2000.

However, HQCF is expected to meet some minimum requirements by the industry before it is adopted. These include price competitiveness, consistency of quality, and all year round availability in the required quantities. Specific quality criteria for HQCF have been set by the industry (Tables 2 & 3). The inability of small-scale processors to meet the minimum quality set by industrial users of HQCF can be resolved by adopting a suitable quality management system.

1.4 METHOD OF DISTRIBUTION OF HQCF

The method of distribution will depend on the type of end-user being targeted. Outlined below are the various categories of end-users and the recommended modes of distribution.

Domestic end-users, home bakers and other low level users

Linkages must be established with identifiable baking flour retail outlets or shops and supermarkets for supply of HQCF. 1 kg, 2 kg, 5 kg and 10 kg packages may be used for sale of HQCF alongside other forms of flour such as maize or wheat flour. The arrangement should ensure that the retail outlets make reasonable but attractive profits from the HQCF sales.

Commercial bakeries, industrial and other large scale end-users

Conscious business contacts must be made with large scale end-users. Orders for supply of HQCF must be honored by prompt delivery to the end-users with a reasonable surcharge for transportation. The end-users may arrange to collect the consignment from the HQCF processing plants. To create a unique trade identity for HQCF, a maximum weight of 40kg per bag should be adopted for delivery to large-scale end-users such as biscuit and noodle factories that use other types of flour (e.g. wheat, maize, etc.) in their products. This will help to avoid mistaking wheat flour for HQCF in the store or at the processing-floor.

Commercial wheat or maize flour mills

Flour mills should arrange to collect grits/granules or dried chips from the cassava processing plants (in unit packages of their choice). It is not important to mill the grits/granules or dried chips at the small- or medium-scale HQCF plants before delivery to the commercial flour mills since the flour mills will blend with other grains before milling to a composite flour.

Exporters and importers

Exporters/Importers must arrange the collection of HQCF in unit packages of their choice from the processing plant. Where delivery by the processing plant is more desirable by the exporter or importer, the location of delivery (door-to-door or door-to-port), a reasonable surcharge for transportation and other related costs are to be agreed upon.

1.5 SETTING UP A CASSAVA PROCESSING PLANT

1.5.1 Site selection

An enterprise engaged in the production of HQCF should ideally be located in a cassava growing area or very near it. This is to ensure timely or regular delivery of sufficient quantity of fresh cassava to the processing plant and avoid spoilage during transportation since cassava is very perishable, and to reduce to the minimum possible, the high transportation cost resulting from its bulkiness. Specifically, the site should be selected with the following considerations in mind:

- all year round availability of required quantities of cassava roots,
- easy and low cost of transportation of fresh roots to the plant,
- easy access to clean water,
- availability of labor, and
- access to electricity, if electrically powered machinery is to be used.

It is recommended that a HQCF business enterprise, which is to be located in an urban area for proximity to the targeted markets should not engage in processing of fresh cassava roots but be involved in drying, milling, and packaging of already dewatered cassava. Processing plants to produce such dewatered cassava should be located closer to sources of cassava roots.

1.5.2 Building/ Structure

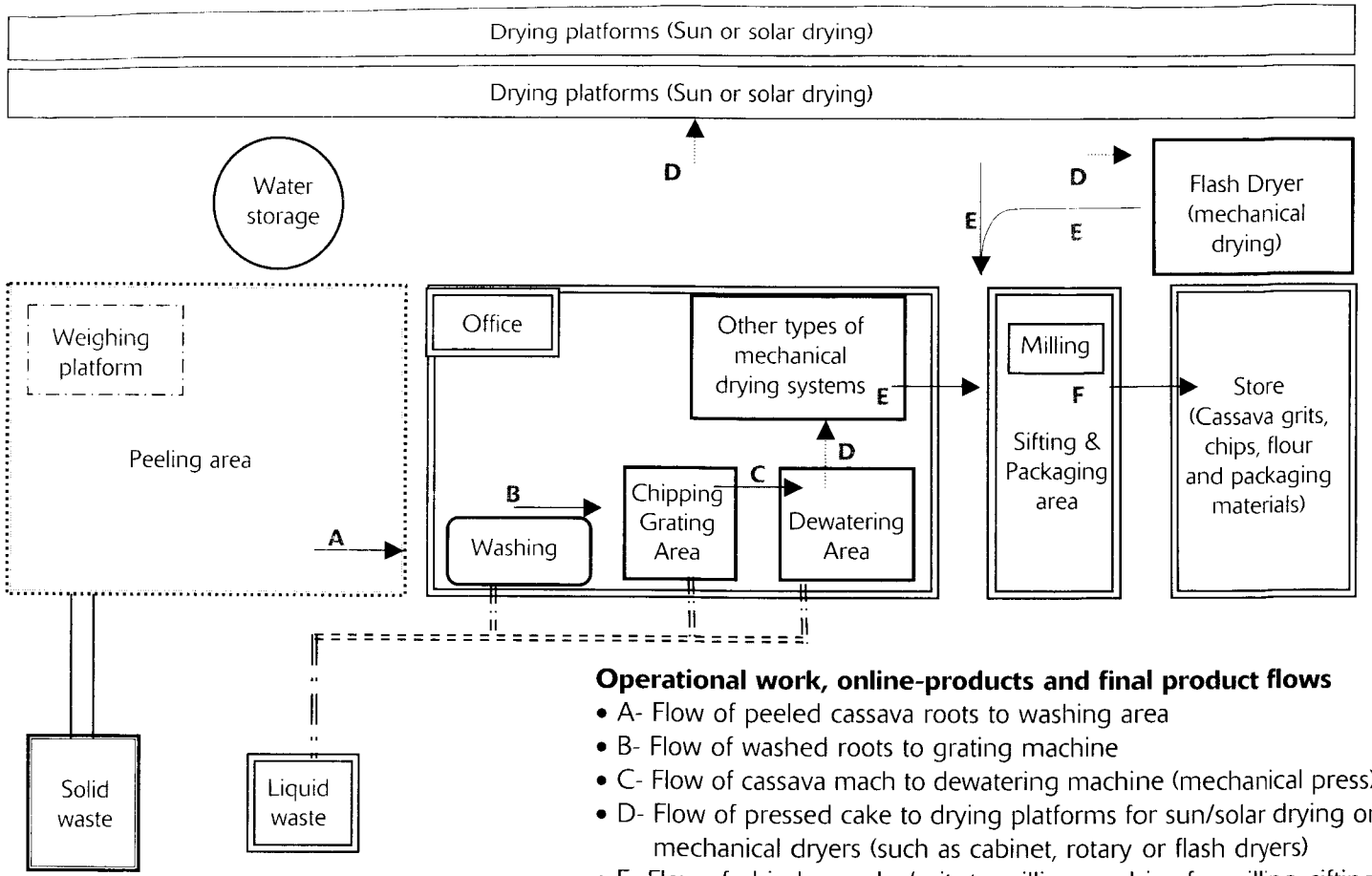
The building/structure provided for processing should be spacious enough to allow for free movement of staff and materials. It should also be high enough and with adequate windows or openings provided to ensure maximum ventilation. A height of about 12 ft (3.53 m) is recommended. It is also recommended that mosquito netting be fixed on windows and trap doors to keep out flies and other insects.

1.5.3 Equipment and plant layout

This is site or plant-specific. However, the major equipment used in HQCF processing plants include mechanical graters, dewatering machines/ press (manual screw/types, mechanical types based on hydraulic systems) or centrifuges, sun drying platforms or mechanical dryers (cabinet, rotary, fluidized bed, flash, etc.), grinding or milling machines (plate, attrition, pin, or hammer), and flour sifters. Others are water supply system (water well/bore hole, storage tanks) piping, weighing, filling, bagging and storage systems.

The layout, i.e. equipment and facilities arrangements, should be such that operational processes from the reception of fresh cassava roots to peeling, washing, grating or chipping, de-watering, drying of de-watered cake, milling of dry grits into flour, packaging and storage can flow smoothly. Interruptions in the sequence of flow of raw material (roots) and intermediate products during processing should be very minimal.

During equipment selection and installation, adequate consideration and provision must be given to ease of machine, floor and plant cleaning. Ample space should be available for movement of workers and for prevention of microbial or physical cross-contamination of on-line or final products, and prevention of personal injury. Heat exchangers should be located outside the plant wall but within the factory fence. The peeling section of the plant should preferably be separated from the other unit operations, possibly under a different roof. Reasonable distance should be allowed between the wet (peeling, grating, dewatering, pressing) and dry (drying, milling, sifting, packaging etc) sections. Consideration should also be given to disposal of wastes (peels, water, and liquor) and to prevent influx of insects and rodents. Adequate supply of clean water, drainage system and facilities for cleaning and hand washing should be provided inside and outside of the processing plant. Toilets should be far away from the processing, drying and storage areas. A recommended floor plan of machinery layout and operational workflow is shown in Figure 2.



Operational work, online-products and final product flows

- A- Flow of peeled cassava roots to washing area
- B- Flow of washed roots to grating machine
- C- Flow of cassava mach to dewatering machine (mechanical press)
- D- Flow of pressed cake to drying platforms for sun/solar drying or mechanical dryers (such as cabinet, rotary or flash dryers)
- E- Flow of dried granules/grits to milling machine for milling, sifting and packaging
- F- Bags of cartons for packaged HQCF flour to the store ready for sale or marketing

Figure 2.**Typical floor plan for a high quality cassava flour production plant**

1.6 QUALITY MANAGEMENT

Quality is the fitness of a product for use by consumers. The nutritional, sensory, safety, convenience, aesthetic and health values of HQCF must be maintained for all customers - industrial as well as individual users.

1.6.1 Evolution of quality management

The management of quality has gone through distinct phases – from being a purely inspection-based control system through assurance to total quality management. The observed inefficiencies at each phase led to the evolvement of the next phase. The identifiable phases of the evolution process are:

- Quality Inspection
- Quality Control
- Quality Assurance
- Total Quality Management

Under quality inspection, inspection of goods and services—to make sure that what's being produced is meeting all expectations—takes place at the end of the operations or process. Under such a system, one or more characteristics of a product are examined, measured or tested and compared with specified requirements to assess its conformity. Products which do not conform to specification may be scrapped, reworked or sold as lower quality items.

The limitation of this system is that it fails to address root causes because it is an after-the-fact screening process with virtually no prevention content. In quality inspection the problem is addressed after it has occurred.

This limitation led to the emergence of the second phase of quality management which is quality control. Under a system of quality control, product testing and documentation control became ways to ensure greater process control and increased conformity. Typical characteristics of such systems were performance data collection, feedback to earlier stages in the process and self-inspection. Quality assurance came with a shift from product quality to system quality. Here an organization sets up a system for controlling what is being done and the system is audited to ensure it is adequate both in design and use. A major part of this shift is the use of both second party and third party audits to assess the efficiency of the system. The major characteristics are the use of quality manuals, procedures, work instructions, quality planning, audits etc. The fundamental difference is that quality assurance is prevention-based while quality control is inspection-based.

Total quality management is the highest level of quality management. In addition to all aspects of quality assurance, it involves the application of quality management principles to all aspects of the business. Total quality management requires that principles of quality management be applied in every branch and at every level in an organization. Typical of an organization going through a total quality process there would be a clear unambiguous vision, reduced interdepartmental barriers, more time spent on training, excellent supply system and customer relations, and realization that quality is not just product quality but also the quality of the whole organization, including sales, finance, personnel and other non-manufacturing functions (Zhang, 1997).

1.6.2 Hazard/Quality analysis critical control point (HACCP/QACCP) system

The Hazard analysis critical control point (HACCP) system is concerned and deals primarily with controlling and ensuring the safety of food products. It is a scientific and systematic approach to identifying hazards and providing measures for their control to guarantee food safety. It involves monitoring and controlling of materials, and processes which could lead to a compromise in the safety of the final food products. However, from the standpoints of food manufacturers and consumers, the quality of food is as important as the safety. Despite that food quality systems are often complicated and expensive to implement, food manufacturers implement them as a matter of priority to produce products that meet the minimum quality standards and in compliance with the food and drug regulations of the countries where the products are to be consumed. Quality Analysis and Critical Control Point (QACCP) was developed by relying on simple but well planned techniques to address both the quality as well as the safety of food products during processing. The HACCP/QACCP system therefore falls under Quality Assurance as well and can be applied during production of HQCF.

The application of QACCP system to HQCF production thus ensures control of input materials and processing procedures to produce high quality cassava flour that meets the predefined quality characteristics. This control may, very well include for example, control of cassava cultivar to indirectly ensure chemical safety through low cyanide content of the final product.

To ensure effectiveness of the quality systems, it is often important to implement some prerequisite quality programs in HQCF production before HACCP/QACCP. Two of such prerequisite programs are Good Manufacturing Practice (GMP) and

general principles of Food Hygiene or Good Hygiene Practice (GHP). Even though HACCP/QACCP can be simplified to a level where it can be easily implemented by SMEs using techniques such as measurement of pH with pH paper, timing of operations, physical observation and inspections, etc, it often still involves extensive documentation and laboratory analysis of samples for verification.

HACCP-like system

To simplify the system further for ease of implementation by SMEs, the HACCP/QACCP systems for producing high quality cassava flour may be implemented without the 6th and 7th principles of HACCP, i.e. with no rigorous record-keeping nor verification schemes. However, emphasis should be placed on identifying hazards and their critical control points, establishing critical limits for preventive measures and a monitoring procedure (Forsythe and Hayes, 1998).

1.6.3 HACCP/QACCP team

Every SME involved in the production of HQCF should have a HACCP/QACCP team in place to carry out the HACCP/QACCP implementation and monitoring as well as taking corrective actions when necessary. The team should have the appropriate knowledge of HQCF production and expertise. It should normally consist of:-

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

  At least one should have Food Science/ Microbiology or Food Chemistry/ Biochemistry background.
- Engineer, Equipment or Machinery Technician
- Marketing/Distribution Manager
- Supporting Junior Staff

This multidisciplinary team should be given strong support by top management and should have very firm commitment to the application and funding of the HACCP/QACCP application. 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.

PART II

HAZARD/QUALITY ANALYSIS CRITICAL CONTROL POINT SYSTEM FOR THE PRODUCTION OF HIGH QUALITY CASSAVA FLOUR (HQCF)

2006

2.1 THE SEVEN PRINCIPLES OF THE HACCP/QACCP SYSTEM

The HACCP/QACCP system for production of HQCF deals with identification of hazards or unit operations that if not properly handled can cause food borne diseases or quality defects, and taking actions to prevent and control the hazards to guarantee quality and safety. The hazard/quality analysis and critical control point system should be applied to all stages of HQCF chain; raw materials, harvesting, processing, storage and distribution. As a hazard prevention-oriented measure, the system is cost effective, reduces product loss due to spoilage, promotes the quality and safety of foods thereby enhancing confidence in food business and trade. The seven guiding principles of this system to which the HQCF production processes are subjected include the following:

Principle 1: Identification of potential hazards/quality defects

All undesired microorganisms, toxins and quality defects associated with HQCF must be identified; for example HQCF should be free from unacceptable biological/pathogenic, chemical or physical contaminants. Fertilizers and pesticides that may have been used in the cassava production should not leave residues and heavy metals in the HQCF at qualities which may constitute health hazards/quality defects (see Table 3). High quality cassava flour should be free from pathogenic microorganisms and should not contain microorganisms or their products (mycotoxin) in amounts hazardous to human health. It should also not contain natural plant toxins (e.g., cyanogens) above the limits allowed. Proliferation of spoilage microorganisms can occur on fresh roots not processed soon after harvesting. Similarly, if the processing is delayed, unwanted microorganisms may invade the cassava roots and on-line products cause fermentation, pH drop, increase in acidity, bad color and repulsive odor. It is important to identify the potential hazards/quality defects associated with the HQCF at all stages of the production and identify preventive measures to control them. The shelf-life of HQCF depends on the moisture content of the final product after drying. The higher the moisture contents of HQCF or of its intermediate products – chips and grits, the shorter the shelf life. Chips and grits must be dried to a moisture content of 10% or less and if not milled immediately, should be stored in clean airtight bags to avoid moisture re-absorption, growth of moulds or weevil infestation.

Principle 2: Establishing critical control points (CCP) for HQCF

Every small- or medium-scale HQCF enterprise must strive to identify each processing step or procedure, from harvesting of cassava roots to distribution of HQCF, which when properly managed or controlled can help in eliminating or

minimizing the occurrence of the identified hazard/quality defect. Since CCPs may vary from one enterprise to the other depending on the processing technology adopted, the raw materials, types of machines in use, and the environment, etc., the associated CCPs need to be identified by the HACCP/QACCP team of every processing enterprise.
Understanding the operational procedures for HQCF production as presented in Appendix I will be necessary in identifying critical points (CCPs) that have major effects on quality attributes, the necessary quality control variables during HQCF production and in setting up appropriate preventive measures against occurrence of safety and quality defects.

Previous investigations by IITA, FRI, and CFC-projects in some sub-Saharan African countries, including Ghana, Madagascar, Nigeria, Tanzania, and Zambia have helped in identifying some of the vital CCPs for the production of HQCF. The results have been used to develop the HACCP/QACCP plan shown in Figure 3. In the figure, CCPs were identified at the points where contamination from raw materials, hands of processors, and equipment may occur during processing from raw material supply to packaging and storage of final product. Some control plans and corrective measures for these CCPs are therefore suggested in Table 4. The corrective measures are to be instituted where the occurrence of more than the acceptable level of hazard/quality defect (such as in Table 3) is envisaged. SMEs involved in HQCF production business can therefore use Figure 3 and Table 4 as guides to establish CCPs; design good control plans, and set up proper corrective measures for their HQCF production schemes.

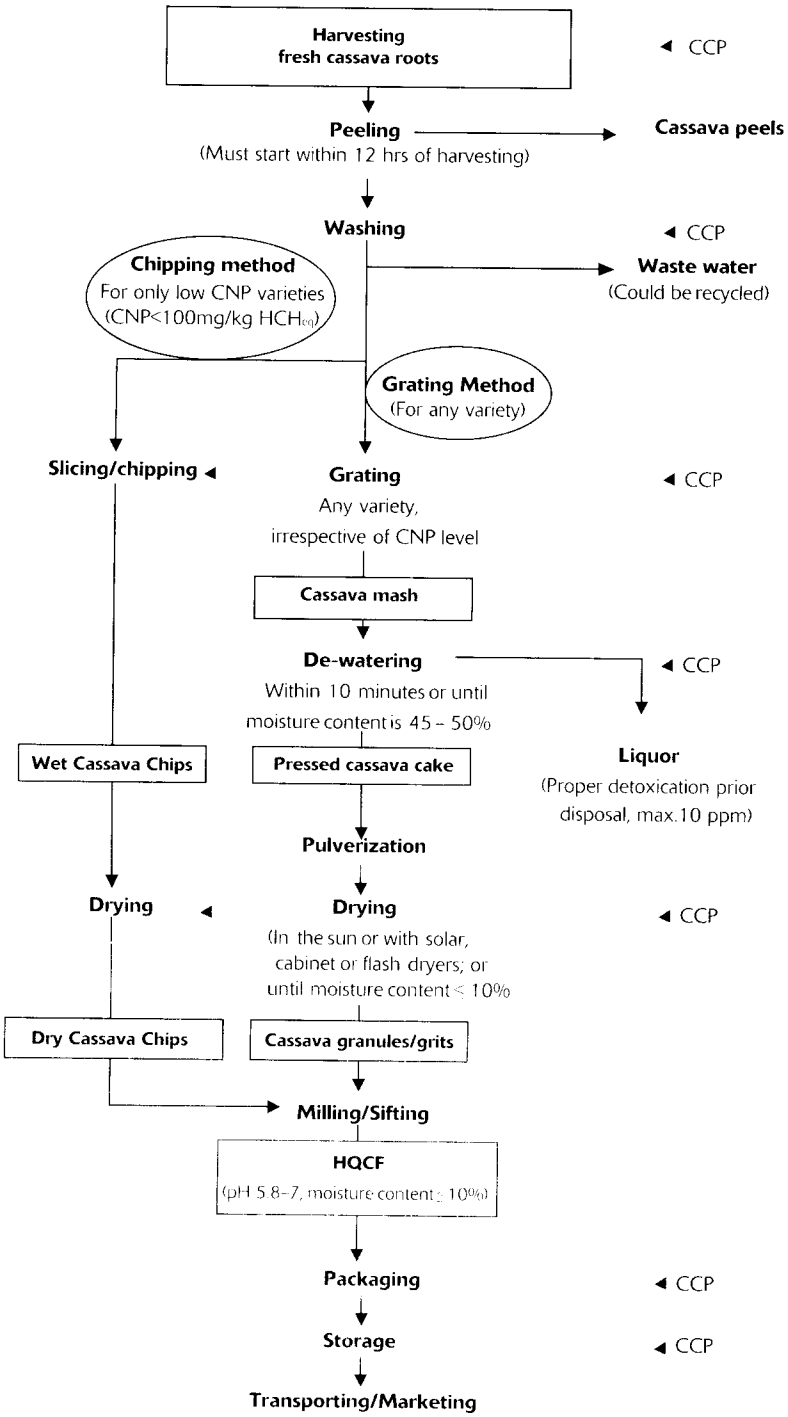


Figure 3. **Critical control points in high quality cassava flour production**

Principle 3: Establishing critical limits

Critical limits are target levels and tolerances which should be met to ensure that the CCPs are under control to produce HQCF that meets the expected quality. The raw materials and online-products have some critical limits that will ensure HQCF produced meets the defined quality. For example, fresh cassava roots are expected to be white or orange flesh with starch content of about 75 – 80% (DM basis), moisture of about 65-70%. Dewatered or pressed cake should have pH of 5.8 – 6.0 and a moisture content of 45-50% or less before drying in the sun or in mechanical dryers. Table 2 shows the quality requirements of most end-users for HQCF while Table 3 shows the regulatory limits for important chemical, biological and physical hazards in cassava flour (not only HQCF) as set by many countries.

Table 2. **Physical and chemical quality characteristics and requirements of HQCF for food uses**

	Characteristics	Quality levels
(a)	Moisture content (MC),	≤10 %
(b)	Starch Content	65-70%
(c)	Total ash on dry matter basis, maximum	3%
(d)	Acid insoluble ash, maximum by mass	0.15%
(e)	Total titrate-able acidity (as lactic)	< 0.25%
(f)	Crude fiber on dry matter basis, maximum	2%
(g)	Pasting Temperature	< 74°C
(h)	Cook Paste Viscosity, minimum	740 BU
(i)	Total cyanogens (CNP)	≤ 10 mg/kg HCN_{eq}
(j)	pH	> 5.8
(k)	Particle size	250± – 500 μ Or at least 90% by mass shall pass through 0.6mm sieve

Abass et al., 1998; Grafham et al., 2000

Table 3. **Limit for chemical, biological and physical hazards in cassava flour**

	Chemical (heavy metals)	**Maximum levels (mg/kg)**
(a)	Lead	0.1
(b)	Arsenic	0.1
(c)	Copper	5.0
(d)	Mercury	0.01
(e)	Tin	15
(f)	Zinc	50
(g)	Iron	22
	Biological (microorganisms)	**Maximum microbial counts (cfu/g)**
(h)	Total plate count	10^4
i)	Coliforms	10^2
(j)	*Escherichia coli*	Nil
(k)	*Salmonella* spp	Nil
(l)	Yeast and mould	10^3
(m)	*Staphylococcus* spp	Nil
(n)	*Vibrio cholerae*	Nil
	Mycotoxin contents	**Maximum levels (µg/kg)**
(o)	Total aflatoxins	10
(p)	Aflatoxin B_1 (not expected to be a problem in HQCF)	5
	Other contaminants (physical)	
	Metal fragments, wood or leaf pieces, sands or stones	Nil

Tanzania Bureau of Standards, 2005; Sanni et al., 2005

Principle 4: Monitoring system

In every cassava processing enterprise, there must be a hazard/quality control plan to ensure that the critical limits or set standards of HQCF are met. Periodic measurements or observations of the CCP during each production must be done.

Principle 5: Corrective action

When the results of the periodic measurements or observations show that any particular CCP is deviating from its specified critical limits, an appropriate corrective action must be effected immediately. This may involve change of raw material, process or machine to keep the CCP under control in order to avoid any associated hazards/quality defects. Products made when a CCP was out of control must be removed, marked unfit and documented.

Table 4 shows a recommended hazard/quality control plan for detecting loss of control at the CCPs and the corrective measures that should be used by the HACCP/QACCP team. The recommended corrective actions are based on field experience of FRI and IITA in the application of the HQCF Production technology and CCPs suggested in Table 3.

Table 4. **Hazard Control Plan and Corrective Measures**

Critical Control Point (CCP)	Significant Hazard/Quality Defect	Control/Preventive measure	Critical Limits for control measure	Monitoring					Corrective Action/Records	Verification
				What	How	Frequency	Who	Records		
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.	Variety name,maturity (months) at harvest; Date and time of harvest.	Investigate from seller	Every batch	Quality Assurance Manager	Name of variety, Age at harvest, Date and time of harvest.	Reject unwanted variety, over-aged or discolored roots.	Moisture content,starch content, discoloration (Use Munsel color chart or book), pH.
	Spoilt cassava	Process soon after harvesting	Process within 8-12 hours of harvesting	Colour change, evidence of spoilage, presence of vascular streaking, presence of brown streak.	Visual inspection	Every batch	Quality Assurance Manager	Degree of discoloration	Redirect unprocessed roots supplied more than 12 hrs after harvesting for processing into other fermented cassava products or into chips for animal feed.	
				pH.	pH meter			pH		
Washing	Pathogenic organisms in water used	Use potable water from credible source. Treat water from all other sources before use.	Complete absence of dirt. faecal matter, or offensive odor in water supplied.	Water: dirt, particulate matter, sand, faecal matter, odor,	Visual inspection, smell	Daily	Production Supervisor	Levels of: Dirt or particulate matter, sand, faecal matter, odor, pH and conductivity of water.	Change the water for washing or the source of water.	Carry out microbiological assessment of samples of water and final products: Pathogens, Coliforms, total plate count.
			pH:6.5-8.5, conductivity: , density: , E.coli: Nil, Coliform: Nil	pH, conductivity, density, chlorine, micro-organisms.	pM meter, conductivity meter, densitometer					
	Sand left on washed roots	Ensure that sands and sticky mud are completely removed from all parts and roots' contours.	Complete absence of sand or mud on washed roots.	Washed roots: sand particles and mud	Visual inspection	Every batch of peeld roots	Production Supervisor	Presence or absence of sand and mud particles on washed roots	Alert staff washing/operating washing machine (if any) and rewash.	Simple soil/sand sedimentation tests on dried online or final product

Critical Control Point (CCP)	Significant Hazard/Quality Defect	Control/Preventive measure	Critical Limits for control measure	Monitoring					Corrective Action/Records	Verification
				What	How	Frequency	Who	Records		
Grating	Pathogenic Thermophiles	Use clean grating machines Ensure graters are washed after end of daily operation.	Complete absence of dirt inside and outside grating machines.	Dirt on grating machines.	Visual inspection.	Before grating.	Production Supervisor.	Absence of dirt.	Clean and sanitize graters.	Microbial analysis of final products and swaps from equipment: Pathogens - Coliforms, total plate count.
Slicing/ Chipping	Residual cyanogens	Use only low CNP (sweet) cassava variety in this method of production	CNP 50mg/kg HCN_{eq} in blended 1/4 - sections of peeled root-samples made by longitudinal slicing.	Variety of cassava: Sweetness of cassava.	Enquire from supplier,	Before harvesting and prior to processing.	Quality Control Supervisor	Name of variety, taste of roots (sweet, bland or bitter).	Reject high CNP (bitter) variety for chipping method, and send any batch of high CNP roots for grating. Lean and sanitize chipper	Quantitative analysis of CNP level of on-line products.
				Qualitative CNP level of cassava.	Use picrate paper and color guide (appendix V)			CNP level.		
De-watering	Cyanide	Efficient dewatering to remove liquor with high amount of cyanogens.	45-50% moisture level after pressing.	Degree of dryness of pressed/dewatered cassava	Finger press-feel of pressed/dewatered cassava.	Every 10 min of dewatering, every batch.	Dewatering machine Operator.	Dryness of pressed/dewatered cassava	Increase pressure on the bag of cassava being dewatered.	Moisture content (oven method) Cyanide content or dewatered cassava (cake)
	Pathogenic thermophiles	Use clean polypropylene sacs and clean dewatering machine/press. Never place or drop empty/filled pressing bags on dirty surfaces or on dirty floor. 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.	Dirt on dewatering equipment and sacks.	Visual inspection.	Before, during and after dewatering.	Quality Control Supervisor.	Absence of dirt.	Clean and sanitize sacs. Wash pressing machine after use.	Microbial analysis of on-line and final products; and swaps from sacks and equipment: Pathogens, Coliforms, total plate count.

Critical Control Point (CCP)	Significant Hazard/Quality Defect	Control/Preventive measure	Critical Limits for control measure	Monitoring					Corrective Action/Records	Verification
				What	How	Frequency	Who	Records		
Drying	Growth of Fungi/ mould and their spores; and Aflatoxin production caused by inadequate drying	For sun/solar drying, process flour only during dry weather; start drying early in the day: use very low loading density; ensure complete dryness of grits or chips before milling to HQCF or storage. Incompletely dried grits/chips to be re-dried the next day must not be covered overnight. It must be spread or exposed to draught of air in a well ventilated room devoid of contaminating matter, animals, dust. etc	*Temp.* : Sun: 30-40°C, Solar Dryer: 50-60°C, Cabinet Dryer: 60-65°C, Flash Dryer: 120-150°C;	Ambient temp., Solar dryer temp., Mechanical dryer temp.;	Use of a thermometer;	Every batch of product; For ambient and solar temp -- every 2 hours of drying in sun.	Quality Control Manager	Ambient temp. Solar temp., Mechanical dryer temp.;	Re-dry within specified control limits, or use product for non-food purpose if quality is too low.	Moisture content of dried un-milled products. Mould counts in flour or aflatoxin content of flour.
			Loading Densities: Sun: 5kg/m2; Solar dryers: 5kg/m2; Cabinet dryers: 10kg/m2; Flash Dryer: 250kg/hr	Loading densities for each drying mode.	Weighing and physical measurements.			Loading densities for each drying mode;		
			Drying time: Sun: Day 1 :- 8hrs, Day 2 :- 4hrs; Solar: Same as sun; Cabinet dryers: 7hrs; Flash Dryers: Continuous flow	Drying times.	Timer.			Drying times.		
	High microbial loads caused by use of unclean drying surfaces and materials like drying sheets	Provide clean and hard surfaces at drying sections. Do not place bag of dewatered cassava on dirty surfaces or floor. Adopt routine cleaning and use of disinfectants to disinfect drying surfaces and dryers.	Complete absence of dirt on drying surfaces	Dirt, animal droppings and dust on drying surfaces and materials.	Visual examination of drying surfaces, inside of dryers and other materials.	Start of every drying activity. Every two hours during sun-drying.	Drying Operators	Presence/absence of dirt, droppings and dust before and after drying process.	Drive off pests birds, bees and other animals.	Microbiological quality assessment of final products. Regular swap test of inside of dryers, Pathogens, Coliforms, total plate count etc; Simple soil/sand sedimentation tests.

Critical Control Point (CCP)	Significant Hazard/Quality Defect	Control/Preventive measure	Critical Limits for control measure	Monitoring					Corrective Action/Records	Verification
				What	How	Frequency	Who	Records		
Packaging of HQCF (CCP)	Underweight packages due to leakages resulting from damage to package or improper sealing.	Good sealing of polyethylene bags, cardboard packages and sewing of cotton bags.	No observable openings after sealing of packages. No observable damage to package.	Wholeness and integrity of packages.	Inspection of each unit package before and after packaging.	After every packaging operation.	Packaging Operator.	Identity of packages with leaks or damaged.	Repackage defective products.	Sample and weigh packages in store.
	Moisture absorption by product due to leakages or type of packaging material	Use packaging materials that are not permiable to air nor moisture Polypropylene sacks should be lined inside with thin polyethylene bag.	Flour not exposed to air or contaminants	Wholeness and integrity of packages.	Inspection of each unit of package	After every packaging operation.	Packaging operator	Identity & number of packages with leaks or damaged.	Repackage defective products.	Sample packages and check moisture content.
Storage	Weevil infestation of packaged products	Regular fumigation of storerooms and entire processing area once every three (3) months.	No observable insects in packages.	Last fumigation date.	Inspection of fumigation records.	Monthly	Production Manager.	Number of packages with insects within and number of insects observed in each unit package.	Fumigate plant, sift and re-dry defective products in mechanical dryer; and repackage for immediate supply to non-food end-users.	Sample and check for protein content and microbial load.
		Inspection of unit packages during storage		Presence of weevils in and around packaging and storerooms.	Visual inspection of packagies, processing area and store.	Every two weeks.	Stores Supervisor.	Number of insects found per unit area of processing area.		

Principle 6: Establish procedure for verification of effectiveness of the HACCP/QACCP system

Verification may include validation of established critical limits, review of the HACCP/QACCP system and deviations. These should be done at a specific frequency that will give assurance that the HACCP/QACCP plan and implementation is working. Periodic sampling and analysis of raw material, online materials and final products should be carried out to verify that the HACCP/QACCP system is working properly. For this purpose, cassava processing enterprises should have a laboratory or make arrangements with reliable laboratories for analysis of the samples. In case of the latter, an efficient system of storage and transportation of samples should be set up to ensure the characteristics of the samples do not change before analysis. The HACCP/QACCP team will prepare the list of tests to carry out but will generally include the CNP, pH and moisture contents of the roots and newly produced HQCF. It will also include testing for microbial load, mycotoxin, and moisture of HQCF in storage. Procedures for carrying out most of these tests are outlined in Appendix II.

Principle 7: Documentation and record keeping

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. Sample record forms are attached in Appendix III.

2.2 IMPLEMENTATION OF HACCP/QACCP

The management must be committed to financing the implementation of the HACCP plan. Funds should be allocated to the training and education of staff on implementation of the HACCP plan; to appreciate who is responsible for what, including taking decisions on corrective actions. The responsibilities for HACCP/QACCP implementation, supervision, monitoring of the plan as well as record keeping and documentation must be clearly known by all the factory staff. There must be simple and clear work instructions for the monitoring of CCPs and recording sheets must be designed for the use of staff.

2.2.1 Gap analysis

As a first step in the implementation of the quality management system in an existing cassava processing enterprise, a gap analysis has to be performed by a consultant or a suitably knowledgeable person in Good Hygiene Practice (GHP) or

Good Manufacturing Practice (GMP). Such a study will assess the needs of the plant which will have to be met before it can satisfy the basic requirements of the Quality Management System. By preparing a check list based on the basic guidelines of GHP or GMP and thoroughly examining the physical facility, operations of the plant and the existing quality management system if any, the gaps which exist between the plant and what it is envisaged to be with respect to GMP and application of QACCP can be identified. Renovations, modifications, and other adjustments in design and operations which are assessed to be necessary should be documented and presented to the management of the processing plant. The management will have to carry out these modifications after which the plant will be ready for implementation of QACCP.

2.2.2 Implementation process

The first step in the implementation process is that the Plant Manager will meet the management team to introduce the HACCP/QACCP concept and explain the benefits of the system as well as its demands on management. Thereafter, management should draw up a time table for implementation of the system as follows:

- Meeting with general staff to introduce the concept etc.,
- Formation of the HACCP/QACCP implementation team,
- One-day workshop to train and educate supervisors on the HACCP/QACCP concept and their roles in making implementation of the program possible,
- One-day workshop to train and educate staff on the HACCP/QACCP concept and their roles in making implementation of the program possible,
- Preparation of all forms required for record keeping and assembly of logistics (files, filing cabinets, computer systems etc.,) for documentation,
- Application of the concept begins,

- Management would meet all staff to introduce the concept, its benefits and demands on staff and announce a time table for its implementation as well as the composition of the HACCP /QACCP iImplementation team.
- Regular or quarterly training and education of different categories of staff on personal hygiene and good manufacturing practice (GMP).

2.2.3 Management of the HACCP/QACCP system

Supervision

The Chairman of the HACCP/QACCP team shall be responsible for the implementation of the system. The supervisors being recommended to be responsible for the various control, monitoring and corrective actions are listed in Appendix IV.

- The Production Manager shall be responsible for most of the control actions except where otherwise specified.
- The Quality Control Supervisor shall be responsible for most of the monitoring actions except where otherwise specified.
- The Quality Control Supervisor shall also be responsible for the collation of all records.
- The Quality Control Manager shall be responsible for the documentation of all records.
- The Plant Manager shall be responsible for overseeing the overall implementation of the system acting through the Chairman of the HACCP/QACCP implementation team.

Audit

An audit should be carried out once or twice yearly to ensure all activities intended to be carried out under the HACCP are being applied correctly, and that the results of monitoring, verification and corrective actions are being well recorded and kept properly. The auditors will prepare a report for the management.

Management review

The HACCP team should review the entire quality management system once or twice yearly based on the monitoring, verification, corrective actions, complaints and audit reports. The review will consider the recommendations of the auditors' report and development in quality management and institute corrective actions and modifications to the quality system, if necessary.

PART III

PRINCIPLES OF GOOD MANUFACTURING PRACTICES FOR HIGH QUALITY CASSAVA FLOUR PRODUCTION

2006

3.1 GOOD MANUFACTURING PRACTICE FOR HIGH QUALITY CASSAVA FLOUR PRODUCTION BY SMALL - AND MEDIUM - SCALE PROCESSORS

3.1.1 Fresh cassava production farm

Cassava farms should be located in environments free from hazards. Plant pest and disease control measures, biological pest control measures, the application should be undertaken with chemical, biological or physical agents under the supervision of agricultural experts with thorough understanding of the hazards involved including the possibility of toxic residues being retained by the crop. Farmers should be trained in good agricultural practices, such as non hazardous pest control measures, the application of fertilizers, farm hygiene and how to store hazardous chemicals. Weeds must be controlled and destroyed on fields and soil must be well conditioned to allow maximum yield. Diseases must also be controlled and managed effectively. Where possible, records on chemical and fertilizer application regimes as well as farm hygiene records should be kept for reference.

3.1.2 Design of processing facilities

High quality cassava flour processing plants should not be sited close to environments of high industrial pollution. The land should slope well and should have proper drainage system. Construction or design of facilities should permit adequate arrangement, maintenance, cleaning and functioning of equipment as well as keeping out pests. The internal design should be ideal for GHP and protection against cross contamination during operation. Structures should be solid and built with durable materials, which are easy to maintain, clean and disinfect. Design should minimize dust from flour during production. Walls, floors should be smooth, impervious and easy to sweep and wash. Ceilings and roofing should be well finished to minimize build-up of dirt, condensation and the shedding of particles. Windows should have insect proof net screens that are easy to clean and allow proper ventilation to minimize dust and allow hydrocyanic gas (HCN) to be removed.

Food contact surfaces should be easy to clean, disinfect and maintain and should be non-toxic to high quality cassava flour. Cyanogens react with iron, so equipment made with this metal should be used with caution. It is recommended that surfaces of equipment which will have contact with cassava should be made with stainless steel materials. All equipment used for peeling, washing, grating, de-

watering, drying and milling should be designed to achieve the desired quality specifications for HQCF. There should be monitoring devices available to check products during production. Facilities should be available for cleaning, handling waste and ensuring personal hygiene. Personnel should have protective clothing, nose and mouth guards as well as hairnets. There should be adequate natural ventilation, good lighting and storage facilities, which is ideally segregated and prevent access to and harborage of pests.
If bigger productions are taking place under roof, chemical work hygiene must be ensured if high-cyanide cultivars are used.

3.1.3 Control of operations

All SMEs processing high quality cassava flour should implement an HACCP/HQCCP program to guarantee the safety and quality of their products. Monitoring procedures to check against chemical, microbiological and physical contamination of product should be set up. Packaging materials for HQCF should provide adequate protection from damage, contamination, accommodate proper labeling and must not react chemically with the product. It must be impermeable to water and air.

Records of processing, production, and distribution if kept will enhance the credibility of the food safety and quality systems. Personnel must have requisite skills and training in food hygiene principles and practices and be able to judge potential risks, take appropriate preventive and corrective actions. Products revealed to be hazardous to health should be recalled from markets and not sold for human consumption.

3.1.4 Maintenance and sanitation

Equipment should be well maintained to facilitate sanitation procedures, function as intended and prevent contamination. In particular, metal deposits from attrition mill resulting from poor adjustment of the mill plates, jewelry (earrings, rings, bands, etc), and contaminants such as greases, lubricating oil and cleaning chemical residues should be avoided in HQCF. Physical and chemical cleaning as well as disinfection should be carried out but cleaning chemicals should be handled carefully and properly kept from the online-products, final product and HQCF store. Gross debris, loosen soil and dust should be removed and rinsed off before disinfecting. Holes, drains and other access routes of pests should be sealed, wastes disposed of promptly and any pests present in the plant should be eradicated. Responsible personnel must monitor and check effectiveness of

cleaning and sanitation systems; keep records of cleaning regimes and conduct regular auditing of premises for sanitation and hygiene.

3.1.5 Personal hygiene

Staff should maintain a high degree of personal hygiene and cleanliness always. Personnel who are injured or sick should not handle online-products and final product and should be made to undergo medical examination. Health conditions which must be reported to management include diarrhea, vomiting, fever, skin lesions, jaundice and discharge from ear, eye or nose. Cuts and wounds should be covered with waterproof dressings.

In addition, 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 the contamination of online-products and HQCF.

Personnel must be prevented from smoking, spitting, chewing gum, sneezing or coughing near unprotected food materials. Wearing of personal effects such as jewelry, watches, pins, bracelets, bands etc. should be discouraged. Visitors must wear protective clothing and adhere to all personal hygiene requirements.

3.1.6 Transportation

During transportation of HQCF, breakage or puncture of sacks and contamination of the packaging and products should be avoided. Vehicles must be cleaned and disinfected where necessary. Ideal temperatures and humidity should be maintained and dust and water must be avoided from coming into contact with semi-finished dried products and packaged HQCF.

3.1.7 Product information and consumer awareness

Practice first-in-first-out (FIFO) principle of stocking. Mark product containers for Lot identification and trace-ability. All HQCF intended for the consumer market must bear adequate information for the safe and correct handling, storage, preparation and use of the product. All must be labelled with date and year of production.

3.1.8 Training

Personnel should be trained to make them aware of their roles and responsibilities in protecting high quality cassava flour from contamination or deterioration. Those handling cleaning chemicals and other potentially hazardous chemicals should also be trained on safe handling procedures. Training focus should include:

- Nature of high quality cassava flour
- Manner of handling and packaging high quality cassava flour
- Condition of storage
- Expected length of storage before it expires
- Further preparation before consumption etc.
- Hygienic conduct and basic food hygiene.
- Maintenance and sanitation of structures and buildings
- Cleaning and sanitation procedures for working tools and equipment.

The training programs should be reviewed regularly to meet individual personnel's level of knowledge and understanding.

3.2 DISINFECTING PROCEDURES AND IN-PLANT SANITARY MANAGEMENT PROGRAM

3.2.1 Cleaning aids

Stiff brooms, soft brooms, soft brushes, hard stiff brushes, mop buckets, vacuum cleaners with accessories, net sponges, mechanical scrubbers, mops, squeegees, sweeping brushes, long handled brushes, water hoses, dusters, etc.
cleaning chemicals may include detergents in the form of soaps, disinfectants, quaternary ammonium compounds, etc.

3.2.2 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 the 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

3.2.3 Cassava grating machines

- Disassemble grating compartments at the close of daily operation and clean off all grated cassava residues using brushes and water.

- Wash off residues of cassava from outlet chute, hopper, and rinse off residues by spraying water from water hose.
- Leave to dry after cleaning before reassembling. Avoid entry of water into motor or engine of machine.

3.2.4 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.

3.2.5 Sun-drying platforms and mechanical dryers

- Remove black polyethylene sheets and wash in large volume of water after every drying operation and dry by hanging on drying lines.
- Fold dry polyethylene drying sheets and keep for subsequent drying operations
- Use brooms or brushes to brush off dust from drying platforms before re-laying drying sheets for drying operations.
- Apply disinfectants to wooden frame surfaces to kill germs.
- Where practicable the entire premise for drying should have hard cemented floors that will minimize dust. Use net screens to cover products spread on drying sheets.
- Mechanical dryers should be cleaned before and after every drying operation.
- Wipe food contact surfaces such as drying trays and body of the dryers with damp sponge. Clean and dry the wiped areas with clean and dry sponge or cloth.

3.2.6 Milling machines

Most milling machines designs are attrition, pin or hammer.

- Open milling chambers to clean milling plates and compartments using soft brushes and dry cloth after every milling operation.
- Clean hoppers of mills by dusting off all residues of HQCF.

3.2.7 Sifters and screens

- Remove sieve baskets of sifters and agitate in copious quantities of water to remove all flour. Do not use hard brushes in the cleaning of screens since this could result in the damage of screen and increase of screen aperture. Use very soft brushes only.
- Ensure total dryness of sifters and screens before use

3.2.8 Walls, floors, windows and roofs

- Brooms and brushes must be used to scrub and clean walls and floor, and dirt hosed away down drains. High-pressure jets must be used for relatively inaccessible spots covered with tenacious soil which cannot be dealt with by a brush. This type of cleaning should be done often for wet processing areas of cassava such as the peeling, grating, and de-watering or pressing areas. Smooth floors may be dried using rubber squeegees. Rubber strips of squeegees must be pressed in close contact with floor by pressure on the handle and pushed along floor. Walls and floors must be mechanically scrubbed with detergent solution rinsed and dried.

- For warehouse and storage room floors however, vacuum cleaning of floor must be done to remove dust or spilled dried materials. Appropriate vacuum cleaning attachments (or other alternative means) must be used to clean roof girders and collect dust. Roof girders must be cleaned before floors. Order of cleaning must be planned so that dirt is washed down onto a surface to be cleaned and not one that has already been cleaned. The floor should be the last to be cleaned. Scrubbing and mopping of floors, cleaning of window and window screens must be done using clean water or vacuum cleaning.

3.2.9 Don'ts of Sanitation Management Programme

- Do not clean any machine (chippers, grater, press, mechanical dryer, mill, sifter or screen) when it is in operation, unless if required as part of cleaning procedure
- Prevent water from entering electrical parts of machines.
- Do not clean machines until the electrical switches are in off position.

Remember to apply grease or the appropriate lubricants immediately after greasy areas are cleaned.

3.3 WATER SUPPLY AND WATER QUALITY MANAGEMENT

3.3.1 Water supply management

The following water supply sources are recommended in decreasing order of preference for processing:

- Potable pipe-borne water
- Water from a bore hole
- Water from a dug-out well, and
- Harvested rain water

Potable pipe-borne water should be the first choice of water for processing cassava into HQCF. In the absence of pipe-borne water, water from a bore-hole should be the next choice.

Water from a running river source may be used in the absence of all the above options but must be handled with great caution and subjected to very rigorous treatment before use. With the exception of pipe-borne water, water from all other sources should preferably be subjected to chlorination and filtration before use especially if there is suspicion of some forms of contamination. Other recommended treatments (if affordable) include:

- Deodorization by passage through a carbon column
- Sterilization by passage through a U-V sterilizer

Water from a running river source should be subjected to all the above treatments before use. When it becomes necessary to treat the water before use expert advice must be sought before the recommended treatments are carried out.

Adequate systems should be installed to ensure that water supplied for processing is clean and safe. A regular inspection (preferably weekly) of the water supply system should be carried out to ensure water availability in quantities required for all processing, cleaning, washing and sanitation activities scheduled for each week.

3.3.2 Water quality management

Water quality is determined by assessing the microbiological, chemical and physical characteristics. Biological characteristics refer to the number and types of microorganisms present. Chemical characteristics include pH, alkalinity, hardness, nitrates, nitrites, ammonia, phosphates, dissolved oxygen, biochemical oxygen demand, conductivity and density. Physical characteristics include the odor, color, presence of particulate matter and taste.

For the purposes of processing cassava into HQCF, the biological quality of water is very important. The parameters of utmost importance and which should be assessed include presence of pathogens, coliforms, total plate count, yeast and mould counts. In addition, selected parameters like odor, pH, conductivity and density from the physical and chemical attributes could give useful indications of the physical presence of pollutants in the water and should be assessed. Selected water quality specifications that should guide the quality control manager in ensuring that the quality of water provided for processing is acceptable and safe

are provided in Table 5. Samples of water should be taken at source at delivery points and assessed:

- Daily for the physical and chemical attributes, and
- Weekly (or upon strong suspicion of contamination or pollution) for microbiological attributes.

Table 5: Water Quality Standards

Parameter	WHO Guideline Values (Max. Limits)
Appearance and Taste	Should be acceptable
Colour	15 TCU
Turbidity	5 NTU
Total Dissolved Solids	1000 mg/l
pH	6.5 – 8.5
Total Hardness	500 mg/l
Iron (Fe)	0.3 mg/l
Sodium	200 mg/l
Potasium	30 mg/l
Calcium	200 mg/l
Magnesium	150 mg/l
Manganese (Mn)	0.5 (P) mg/l
Chloride (Cl)	250 mg/l
Fluoride (F)	1.5 mg/l
Nitrite (NO_2)	3 (acute); 0.2 (chronic) mg/l
Nitrate (NO_3)	50 (acute) mg/l
Ammonia (NH_3)	1.5 mg/l
Sulphate (SO_4)	250 mg/l
Total coliform bacteria	0 coliforms/100ml
E.coli or thermotolerant coliform bacteria	0 coliforms/100ml

FAO (2006); WHO (2006) TCU=True colour units; NTU=Nephelometric turbidity unit

3.4 MANAGEMENT AND CONTROL OF RODENTS, INSECTS (FRUIT FLIES, COCKROACHES, BEES, HOUSE FLIES ETC.), BIRDS, REPTILES, AND DOMESTIC ANIMALS

3.4.1 Rodents

A member of staff must be responsible for monitoring the processing plant for rodents and the assignment should include baiting and recommendations on

repairs that are necessary to keep out rodents. Access to food by rodents must be completely avoided. Small cracks may allow rodents to enter. Therefore, cracks and holes once observed must be sealed or filled appropriately. Containers for storing food must be rodent proof. Traps with baits must be placed along rodent pathways. Anticoagulant rodenticides may be used to kill rodents.

3.4.2 Insects (fruit flies, cockroaches, house flies, etc.)

Regular spraying of environment with insecticides and the use of screen netting must be ensured to eliminate insects. 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. Dark cabinets and drawers must be regularly checked for eggs of cockroaches, thoroughly cleaned and sprayed with insecticides.

It has been found that bees are attracted to cassava grits and chips during sun drying. Therefore special consideration needs to be given to preventing bees from contaminating the materials during sun drying on open platforms or on concrete surfaces. Beehive close to drying areas should be identified and carefully removed.

3.4.3 Birds, reptiles and domestic animals

These must be continuously monitored and eliminated by appropriate means to avoid product contamination especially during drying of pulverized cake in the open.

3.5 ENVIRONMENTAL IMPACT

Although no hazardous chemical is used during HQCF production, the peels of fresh cassava and effluent from washing and pressing operations; noise and sooth from cassava graters, chippers, electricity generators, mechanical dryers, mills and sifters constitute nuisance to the processing environment. In addition, some types of sifters, screeners and milling machines, particularly those without or with ineffective cyclone separators cause air pollution due to escape of cassava flour during processing.

Of all these, the accumulation of effluent and peels normally containing the cyanogens - linamarin, cyanohydrins and hydrogen cyanide, removed from cassava roots during processing is the most serious in terms of its negative impact on the environment, the health of the processors and rural people, particularly women and children. Run-off from cassava processing plants if not adequately

treated can cause pollution and damages to the ecosystems along its path, nearby streams, rivers and underground water. The cumulative effect of these may include accumulation of cyanogens in community drinking water and loss of aquatic lives, which may further expose the community to cyanide toxicity through drinking of underground water or eating of fish and other foods from nearby rivers.

It is important for all cassava processors to device adequate measures to minimize or eliminate the dangers posed by the pollutants and toxins released during processing of cassava. Adequate monitoring scheme such as regular environmental impact assessment by qualified personnel or institution in addition to regular hospital surveillance reports should be implemented to ensure that the measures put in place are working.

CONCLUSION

This manual has provided sufficient information and adequate guidelines that lay the foundation for entrepreneurs to implement quality systems and adhere to hygienic practices for the production of High Quality Cassava Flour (HQCF). A detailed generic quality management system for HQCF production has been outlined which requires just minimal adaptation to make it applicable to any HQCF production enterprise. It is expected that the application of the principles outlined would enable processors meet recommended standards for HQCF, thereby improving their access to domestic as well as export markets. It must be emphasized however that the successful implementation of the concepts and principles detailed here would depend to a large extent on the commitment and discipline of the Quality Management Team; and would as well require a lot of hard work and attention to details on the part of plant supervisors responsible for effecting control measures, monitoring and corrective actions. The cooperation of frontline staff is also a key success factor in the implementation of the system. The need for constant education to improve staff's understanding of the rationale behind the institution of the quality system, its benefits and why it must be supported, cannot be overemphasized. The adage that 'whatever is worth doing is worth doing well' must be the guiding principle in the pursuit of quality; and the understanding that when quality is improved, market value increases and the chances for higher profitability increases farmers' earnings and livelihood is improved, should be the driving force behind the endeavour to implement a good quality system. When, finally, success is achieved in the implementation of the quality system, through possible increases in demand for HQCF and higher demand for fresh roots, thereby improving the food security, cash earnings and livelihoods of resource poor cassava farmers, this manual would then be seen to have contributed in putting humanity a little closer to good health, longevity and prosperity.

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APPENDICES

APPENDIX I: UNIT OPERATIONS RECCOMMENDED FOR HIGH QUALITY CASSAVA FLOUR PRODUCTION

Step 1: 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 are in use, HQCF can be processed anytime, rainy or sunshine.
- 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 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 quality of HQCF.
- Harvested cassava should be transported quickly to the processing site and processed (within 8 - 12 hrs 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.
- If HQCF is for food uses and the available technology is the chipping technology, low CNP cassava MUST be processed. Either high or low CNP cassava could be processed to HQCF for food uses if grating technology is used. For non-food uses, there is no danger associated with the choice of variety; any available variety would be appropriate for use with either of the two technologies.

Step 2: Peeling

- Remove woody stalks on the roots. Use wide and broad-bladed 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 be used. There are few designs being developed in Nigeria that could become commercially available soon, but steam peeling may not be suitable. Whatever method is used, there should be no peel fragment after the peeling process.

- Transfer peeled cassava roots into 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 eposure.

Step 3: Washing

- Use potable water from credible source or treat water from 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 complete absence of dirt, sand, sticky mud, faecal 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.

Step 4a: Grating or Rasping

- Grate cassava immediately after washing using a clean mechanized 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.
- The grated cassava mash should be packed into clean polypropylene sacks of tiny woven screen apertures for de-watering. Sacks of cassava mash should never be placed on bare

floor or any dirty surface. They should be held 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.

- Wash cassava grater thoroughly with clean water after grating.

Step 4b: Slicing/Chipping

- Slicing/Chipping as an alternative to grating if a low CNP cassava variety is to be processed. Washed cassava roots could be chipped in a manual or motorized chipping machine. After chipping and if a press is available, cassava chips could be put in a sack and pressed to remove some water prior to drying. Chipping should not be practiced with high CNP or bitter cassava varieties if the flour is for human food. The quality attributes of HQCF may vary depending on the size of chips, drying time and method.

Step 5: De-watering by Mechanical Press

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. Centrifuges are used on a large-scale.

- 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 sack of grated cassava mash (30–40kg) flat on the cassava press platform. Fold the mouth of the sack on top or under the sack of cassava mash or simply tie the sack. Two to five sacks 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 screw/combined screw-hydraulic press. Wooden racks may be placed in between sacks to improve dewatering efficiency.
- Apply load pressure by clockwise screwing of the plate onto the sacks until the maximum pressure level is attained and the sacs are hard. Load pressure reduces as liquor drains out of the sacks; the sacks become softer when tested with finger.
- Repeat the clockwise turning of screw press or operate the hydraulic pressure regularly to maintain load pressure until mash is well dewatered.

- Remove de-watered cassava press cake (check by finger-feel for the hardness of press cake as an indication of a well de-watered press cake before removal). The moisture content of well dewatered cassava cake ranges between 45%–50%; often attained after 10–40 minutes.
- Empty cassava cake into clean pans or bowls for disintegration.

Step 6: Cake Breaking/ Disintegration

- Pressed-cake should be disintegrated into wet granules or grits using a mechanical grater. Hand sifting could be done with a specially woven palm frond or wire mesh of 2mm x 2mm or 2.5mm x 2.5mm aperture size. Lumps of non-grated cassava could be removed when hand sifting is done; leaving the final wet granules to be of uniform size. This improves drying uniformity.
- Use clean containers to hold the wet granules.

Step 7: Drying

- Sun or solar drying: Wet granules or cassava chips should be sun dried by spreading thinly on polyethylene sheets or drying mats (5 kg/m^2) over raised platform.
- Stir drying grits or chips regularly to expose all grits or chips to absolute sun drying.
- Drying should be under constant monitoring to prevent pests, domestic animals, birds and insects, such as honey bees, from contaminating product. Where possible, netting mesh system should be used to cover material being dried. Under high sun ray intensity, it takes 6–8 hours to dry grits or chips completely provided the recommended loading rate (5 kg/m^2) is adopted and regular stirring was done.
- Mechanical (Electrical or diesel-fired) cabinet dryers are used for drying between 60-65°C at a loading density of 10 kg/m^2 by spreading the pressed cake or wet grits thinly on trays in the drying chambers.
- Flash and fluidized bed dryers could also be used for drying grits. Many designs of flash dryers are commercially available internationally, in Brazil, Ghana, Nigeria, etc. Flash dryers dry at operating temperature of 100° - 250°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 7 seconds. Drying capacity of flash dryer depends on many factors but could be as high as10 tones/hour.

- Pack dry grits or chips after cooling into clean containers or sacs for milling into flour.

Step 8: Milling/Sifting

- Pour dried cassava grits or chips into 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 machine after milling
- A harmer mill could be used with a sieve of appropriate aperture size to produce HQCF of required particle size of 250–500μ. Sifting of flour will be necessary if a plate or attrition mill is used.
- Sift the flour with a sifter. Avoid overloading sifter.
- Receive the sifted flour with a clean container and stop the machine when sifting is complete.

Step 9: Packaging/ Labeling

- Package HQCF in suitable, clean, insect, light and moisture proof materials that safeguard the hygienic, nutritional, physical and organoleptic qualities of the product. The packaging material should not impart any toxic substance or undesirable odour or flavor to the product.
- HQCF could be packed in polypropylene sacks (25-50 kg) lined with thin polythene 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.

Label each container 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

Attach to each container a sticker with the inscription 'Store in cool dry place'.

Step 10: 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. The storage conditions must meet the requirements of GMP. Retail packaged products must be stored on shelves during storage.

APPENDIX II: ANALYTICAL METHODS AND PROCEDURES FOR DETERMINING QUALITY DURING PRODUCTION OF HIGH QUALITY CASSAVA FLOUR

Most of the chemical methods outlined in this section are those proposed by Bainbridge et al (1996), Grace (1977), Dubois, et al (1956) and McCready et al (1950). The methods were modified where appropriate. To get reliable results with the methods, it is recommended that instruments for quality analyses such as pH meters, moisture meters, thermometers, weighing scales etc., should be inspected, properly maintained and where necessary calibrated regularly to ensure they are in good working condition.

Quality Checks

The recommended quality analyses consists of a group of selected tests, which together provide the best possible general insight into the usefulness of the raw materials (cassava roots, water, etc.) and final products. The recommended analyses include those for cellulose, ash, viscosity, acidity, water quality, content of cyanogens and microbiological stability. For a SME involved in high quality cassava flour processing some of these analyses should be contracted to reputable laboratories. A few simple routine tests should however be done in-plant while production is still in progress. On the basis of the results of these tests, quality should be designated in the form of a grade and the quality of final products should fall within expected company or regulatory standards before products are cleared as being of good quality for marketing and consumption.

Sampling plans

About 6% of samples of raw cassava supplied should be examined for bruises, rot, decay, maturity etc. Sample sizes for quality checks should be random but decision of rejection or acceptance upon observation of quality defect should be based on tests conducted on random samples from bottom, middle and top portions of composite samples from daily productions.

Maturity test for fresh roots

The maturity and quantity of starch present in cassava roots is affected by the time of harvesting in terms of length and period or season of the year. Selecting a medium size root and snapping it into two constitutes a subjective maturity test. If the root snaps with medium force, the root is generally regarded as mature and the flesh will appear firm, white, and relatively dry. Such roots are considered to

have the maximum starch content. If considerable force is required to snap the root, it is considered to be woody and thus the root is said to have passed its prime. The flesh of immature roots is usually slightly yellow, with a translucent watery core and has low starch content.

pH

Weigh exactly 10g of flour sample into a 250ml beaker. Add 20ml of distilled water and mix well. Further aliquots of water may be required in order to obtain slurry. Wash the pH electrode with distilled water and place in sample. Allow a few moments for reading to stabilize. Record pH value and wash the pH electrode back into sample with distilled water (Bainbridge et al., 1996).

Titratable Acidity

For titratable acidity, transfer the sample for pH measurement into a 250ml conical flask. Wash out the beaker into flask with an excess of distilled water. Add 4-5 drops of phenolphthalein indicator. Fill 25ml burette with 0.1M sodium hydroxide (NaOH). Titrate with the NaOH until the indicator just turns pink. Record the titer volume of NaOH added. Calculation of % titratable acidity (%TTA) as lactic acid is obtained by multiplying the titer volume by 0.09. (Bainbridge et al., 1996).

Moisture

The method of Bainbridge et al. (1996) is proposed for moisture determination. Place 2g of sample of flour in pre-weighed moisture dishes with lid. Dry the flour sample at 105°C for 4hrs with lids slightly open apart. Replace lids and place-dried samples in desiccators for 30min. to cool. Weigh dishes containing the dried samples. The % moisture is calculate by the formula,

$$\% \text{ moisture} = \frac{100\,(w_2 - w_1)}{w_2 - w_3}$$

where:

w_1 = dish weight
w_2 = dish weight + sample weight before drying
w_3 = dish weight + sample weight after drying

Particle Size

Weigh a 100g-cassava flour sample into a pre-weighed sieve of about 250 micron-aperture sieve and sieve sample thoroughly until a constant weight of residue is

obtained. The percentage of flour passing through the aperture is obtained from; 100–weight of sample residue on sieve.
For a flour of good quality over 95% of it should pass through the mesh screen.

Fiber (insoluble cellulose) and Foreign matter

Two to three grams (2 g - 3 g) of flour should be boiled with 100ml of 0.4% hydrochloric acid for one hour in a fume cupboard. Filter the liquid through a weighed crucible fitted with filter paper or through a Jena glass filter. After washing with hot water, dry the crucible at a temperature of 105°C - 110°C until a constant weight is obtained. The percentage of fiber and impurities are calculated as one hundred times the gain in weight of crucible divided by the weight of the test portion.
A rough estimate of fiber is carried out by "crunch" of the flour. That is the sound given when a sample, packed tightly in a small bag is pinched between fingers. "Crunch" is strong in pure flours but above certain fiber content it is lost. This is determined based on practical experience with time. (Grace, 1977).

Cleanliness

Add five milliliters of distilled water to 1g of dried high quality cassava flour. Stire the mixture and then add 5ml of 0.7M NaOH solution. Examine the uniform gelatinized mixture for impurities. The degree of whiteness and clearness depends on the quantity of pigment and dirt present in the flour. (Grace, 1977).

Appearance

Compare brightness or whiteness of flour with a "standard" which is of prime grade and identified as first class quality. If this is not available, compare whiteness to that of barium sulphate and determine the relative whiteness visually. Experience in this method is gained over time. (Grace, 1977).

Taste and Smell

High quality cassava flour should be bland in taste without indication of acidity or off-flavor. The smell should be typically that of freshly peeled cassava. (Grace, 1977).

Total soluble sugars (McCready et al. 1950, Dubois etc al. 1956)

Weigh 50 or 100 mg of sample (ground to pass 60-80 mesh sieves) into the 50 ml centrifuge tube. Wet sample with 1.0 ml 80% ethanol (to prepare 80% ethanol, dilute 1680ml 95% ethanol to 2 liters). Add 20ml distilled water. Mix. Add 10 ml

hot 80% ethanol and mix thoroughly. Centrifuge at 4000-5000 rpm for 5 minutes. Carefully decant supernatant into a 100ml volumetric flask. Add 10ml hot 80% ethanol to the residue. Mix thoroughly and centrifuge for 5 minutes and decant supernatant into the same flask. Repeat the extraction with hot ethanol. Add distilled water to the combined extract up to the 100ml mark.

Determine sugar by the phenol-sulphuric acid method as follows: Pipette 1.0 ml of sugar extract into a test tube. Dilute to 2.0 ml with distilled water. Add 1.0 ml 5% phenol. Mix thoroughly. Add rapidly 5.0 ml concentrated sulphuric acid directly to the liquid surface and not to the sides of the tube in order to obtain good mixing. Allow tubes to stand for 10minutes. Shake or vortex to mix thoroughly. Then place for 10-20 minutes in a water bath at 25-30 ^{o}C (optional).
Absorbance: Read absorbance at 490 nm.
Blanks: Prepare blanks by substituting distilled water for the sugar extract solution.
Standard Curve: Make a standard curve using 0-100µg glucose. Dissolve 10mg glucose in 100ml distilled water. This contains 100µg /ml. Pipette 0.20, 0.40, 0.60, 0.80, and 1.00ml of standard glucose solution into test tube and proceed as with sugar determination (above).

Starch content (McCready et al. 1950, Dubois et al. 1956)
Use residue from sugar analysis. Transfer residue from sugar analysis to a 100 ml volumetric flask with 18 ml of 70% perchloric acid or 15.5 ml of 60% perchloric acid. (To prepare 52% Perchloric acid - Add 270ml of 72% perchloric acid to 100ml water; store in glass-stoppered containers.) Divide the acid into three portions to be able to rinse the tube well. Rinse the tube further with 9.0 ml water. Let it stand for 1-2 hours. Dilute to extract to 100ml with distilled water. Filter through sintered glass funnel or glass wool or equivalent. Pipette 0.2 ml of extract into a test tube and dilute to 2.0 ml with distilled. Develop colour as in the determination of sugar by the phenol-sulphuric acid method

Calculation: The amount of sugar is determined by reference to the standard curve, while taking the dilution factor and weight of sample into consideration.
Express sugars directly as amount of glucose.
To convert to starch, multiply values of glucose by 0.9

$$\% \text{ Sugar} = \frac{\text{Abs} \times 1/\text{slope}}{100 \times \text{weight of sample}}$$

Calculation of Sugar & Starch Contents

$$\textbf{Sugar} = \frac{Cg \times V \times 10^{-6} \times 10^{2}}{\text{Weight of sample}}$$

Where:

$$Cg = \frac{\text{Absorbance} - a}{M}$$

a = Intercept

M = Slope of standard curve

A = Absorbance

V = Volume of extract = $\frac{\text{Total volume}}{\text{Volume of aliquot i.e. (dilution factor)}}$

a = 0,

$$\textbf{Sugar} = \frac{A/m \times V \times 10^{-6} \times 10^{2}}{\text{Weight of sample}}$$

$$= \frac{A \times 1/m \times 100 \times 10^{-6} \times 102}{\text{Weight of sample}}$$

$$= \frac{A \times 1/m \times 10^{-2}}{\text{Weight of sample}}$$

$$= \frac{A \times 1/m}{100 \times \text{weight of sample}} \%$$

$$\textbf{Starch} = \frac{A \times 1/m \times 500 \times 10^{-6} \times 10^{2}}{\text{Weight of sample}} \times 0.9$$

$$= \frac{A \times 1/m \times 5 \times 10^{-2}}{\text{Weight of sample}} \times 0.9$$

$$\textbf{Starch} = \frac{0.05 \times A \times 1/m \times 0.9}{\text{Weight of sample}} \%$$

Krochmal and Kilbride's method of starch determination

This method of determination of starch content of fresh roots may be used by small-scale processors who neither have precision equipment nor highly skilled technical personnel. Root samples should be taken from four different cassava plants from the same farm. During the peak season, cassava roots may be kept in polyethylene bags and stored in a deep freezer. For analysis, slice frozen root samples and blend a weighed quantity (e.g. 100g) with 500 ml of water for 5min. Wash the pulp on a 180μm-sieve with additional 500 ml of water. Discard the fibrous material retained on the sieve. Allow the extract to settle, remove the water and pour the washed material into aluminium pans and dry at about 85°C for 6 -12 hours until a constant weight is attained. Weight the extract and calculate the percentage of starch from the weight and moisture of initial sample (Grace, 1977).

Cyanogenic potential (CNP) analysis

a. Qualitative test (Quignard's test)

Prepare sodium picrate papers by dipping strips into one- percent picric acid solution and then dry. Dip them into 10% sodium carbonate solution and thereafter, dry them again. Preserve these strips of paper in a bottle with tight stopper. Chop finely, a small amount of the roots to be tested and put the chopped roots into test tube. Insert a piece of moist sodium picrate paper, taking care that it does not come into contact with the root pulp. Add a few drops of chloroform and stopper the tube tightly. The sodium picrate paper gradually turns orange if the root material releases hydrogen cyanide. Compare the colour of the picrate strip with that of a preset colour scale of 1-9 (See Appendix 7). The test is a delicate one, and the rapidity of the color change depends on the quantity of free hydrogen cyanide present. (Grace, 1977).

b. Quantitative determination (alkaline titration method)

Weigh 10 to 20 g of blended or crushed root material into a distillation flask, add about 200 ml of water and allow it to stand two to four hours, in order to set free all the bound cyanogens, mean while keeping the flask connected with an apparatus for distillation which already has been filled with the alkaline receiver solution. Distill with steam and collect 150–200 ml of the distillate in a solution of 0.5 g of sodium hydroxide in 20 ml of water. To 100ml of distillate (it is preferable to dilute to a volume of 250 ml and titrate an aliquot of 100 ml) add 8 ml of 5 %

potassium iodide solution and titrate with 0.02N silver nitrate (1 ml of 0.02N silver nitrate corresponds to 1.08 mg of hydrocyanic acid) using a micro burette. The end point is indicated by a faint but permanent turbidity, which may be easily recognized, especially against a black background. (Grace, 1977).

$$HCN\ (mg/kg) = \frac{1000 \times 1.08}{W}$$

where: W= weight (g) of cassava roots used

Microbiological Analysis

Preparation of sample/Serial dilution

Weigh 10 grams of HQCF into a sterile stomacher bag and add 90 ml sterile diluent containing 0.1% peptone, 0.8% NaCl, with pH adjusted to 7.2. Homogenize the diluted sample in a stomacher for 30 seconds at normal speed. From this 1 in 10 dilution, prepare a further decimal dilution by pipetting 1 ml of the diluted sample into 9 ml of sterile diluent in a test tube as the 10^{-2} dilution. Prepare further decimal dilutions by always pipetting 1 ml of the lowest dilution samples into 9 ml of sterile diluent to obtain 10^{-3}, 10^{-4}, 10^{-5}, etc, dilutions.

Aerobic plate count (aerobic mesophiles)

Pipette 1 ml of appropriate decimal dilution in duplicate into sterile petri dishes. Pour 12 to 15 ml of autoclaved (sterile liquefied medium) Plate Count Agar at about 45 ^{o}C into each plate, rotating to mix the contents of each plate thoroughly during pouring. Leave the plates to solidify and incubate in an inverted position (upside down) in an incubator at 30 ^{o}C for 2 to 5 days. Count all colonies on the suitable highest dilution plates containing 25 to 300 colonies and express results as colony forming units per gram (CFU/g).

Yeast and moulds count

Yeasts and moulds may be enumerated on any of the following media; Malt Extract Agar containing 100 mg chloramphenicaol and 50 mg chlortetracycline per liter (MEA), Potato Dextrose Agar (PDA) or Oxytetracyclin-Glucose-Yeast Extract-Agar (OGYEA). The antibiotics should be added after the media has been autoclaved.

Pipette 1 ml of appropriate decimal dilution in duplicate into sterile Petri dishes. Pour 12 to 15 ml sterile liquefied medium (MEA, PDA or OGYEA) at about 45 ^{o}C

into each plate, rotate to mix the contents of each plate thoroughly during pouring. Leave the plates to solidify and incubate upright at 25 ^{o}C or 30 ^{o}C for 5 to 7 days. Count all colonies on the suitable highest dilution plates containing 25 to 300 colonies and express results as colony forming units per gram (CFU/g).

APPENDIX III: SAMPLES OF RECOMMENDED REPORT FORMS FOR MANAGING AND KEEPING RECORDS FROM THE HACCP/QACCP IMPLEMENTATION PROCESS

FORM 1: MONITORING OF RESULTS		
DATE:		
BATCH NO:		
RECORDED BY:		
CCP	**EXAMINATION PARAMETERS**	**RESULTS**
Fresh roots	• 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	Visual Examination • dirt in water • Particulate matter in water • Sand in water • Colour of water • Odour of water • pH of water • Conductivityof water • Density of water • Sand particles on washed roots • Mud on washed roots	
Chipping	• Type of cassava (sweet or bitter) • Qualitative level of CNP	
Dewatering	• Feel of moisture level in pressed cake • Dirt on dewatering equipment • Dirt on sacks	
Drying	• Ambient temperature • Internal temperature of solar dryer • Internal temperature of mechanical dryer • Loading density of sun dryer	

	• Loading density of solar dryer • Loading density of Mechanical dryer • Drying time for sun dryer • Drying time for solar dryer • Drying time for mechanical dryer • Moisture content of final product • Animal droppings on drying surfaces • Animal droppings on drying materials • Dust on drying surfaces • Dust on drying materials • Types and average number of pests observed in drying area • Types and average number of birds observed in drying area. • Types and average number of domestic animals observed in drying area • Types anda verage number of reptiles observed in drying area. • Microbial load of environment/air • Health status of processor	
Packaging and Storage	• Number of packages improperly sealed (ie leaking) • Number of insects or insect parts observed in each packaged unit • Number of packaged units with insects or insect parts within.	

FORM 2: LIST OF CORRECTIVE ACTIONS			
DATE	**CCP**	**CRITICAL LIMIT EXCEEDED**	**ACTION TAKEN**

FORM 3: VERIFICATION RESULTS

DATE: .....

LABORATORY: .....

APPROVED BY: .....

REFERENCE MATERIAL	ANALYSIS	RESULT
FRESH CASSAVA	• Moisture content • Starch Content • CNP of fresh cassava	
WATER & WASHED ROOTS	• Pathogens • Coliforms • Total Plate Count • Extraneous Matter	
PRESSED CAKE	• Moisture content of pressed cake • CNP of pressed cake	
DEWATERING EQUIPMENT & SACKS	• Total Plate count (cfu/g) • Yeast & Mould (cfu/g) • Coliforms (cfu/g) • *E. coli* (cfu/g) • Salmonella (cfu/g) • Shigella (cfu/g)	
UNMILLED PRODUCTS & FINAL PRODUCT	• Moisture content • Mycotoxin (although, unlikely in HQCF) • CNP of final products	
PACKAGED PRODUCTS	• Weight of selected samples of packages in store • Microbial loads.	

FORM 4: TRAINING

EMPLOYEE:

Name .....

Period of employment .....

TRAINING TOPIC	COMMENTS	DATE & SIGNATURE OF PLANT OWNER
Understanding of HACCP and hazards associated with HQCF production.		
HQCF 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.		

FORM 5: MANAGEMENT REVIEW
Date of review: Background material Last management review report:
Last external audit report:
Monitoring reports:
Verification reports:
Corrective action reports:
Customer complaints:
Others:
Main conclusions
Corrective actions and improvements instituted and persons responsible:
Date and signature of plant owner:
Corrective action effected:
Date and signature of plant owner:

FORM 6: LIST OF CURRENT DOCUMENTS

DOCUMENT	DATE OF ISSUE	DATE OF LATEST REVISION	RESPONSIBILITIES	DISTRIBUTION

APPENDIX IV: SUPERVISORS' RESPONSIBILITIES

Handling Control Actions

Control Action Plan	Action needed to be taken	Personnel Responsible
Control Action 1	Selection of roots of appropriate variety and CNP	Production supervisor
	Immediate Processing	Production supervisor
Control Action 2	Water Treatment and supply	QA/QC Supervisor
	Adequate removal of sand and mud from roots during washing	Production supervisor
Control Action 3	Efficient dewatering of grated mash	Production supervisor
	Washing, drying and disinfection of polypropylene sacks used for dewatering	Production supervisor
	Cleaning and disinfection of dewatering equipment	Production supervisor
Control Action 4	Selecting only low CNP varieties of cassava for chipping method	Production supervisor
Control Action 5	Loading of dryers	Production supervisor
	Setting temperature of dryers	Production supervisor
	Cleaning and disinfection of drying surfaces and dryers.	Production supervisor
	Provision of cover screens for open air sun-drying systems	Plant Manager
Control Action 6	Sealing of polyethylene bags	Production supervisor
	Sealing of cardboard box packages	Production supervisor
	Sewing of cotton/polypropylene bags.	Production supervisor
	Fumigation of storerooms and processing area.	Production supervisor
	Inspection of unit packages during storage.	QA/QC Supervisor

Handling Monitoring Actions

Monitoring Action Plan	Action needed to be taken	Personnel Responsible
Monitoring Action 1	Checking and recording of variety and maturity of cassava received.	Production supervisor
	Harvesting date and time of cassava supplied	Production supervisor
	pH of fresh cassava roots	QA/QC supervisor
	Presence or absence of discoloration or vascular streaking on cassava supplied.	QA/QC Supervisor
Monitoring Action 2	Dirt, Particulate matter, sand, faecal matter, and odor of water.	QA/QC Supervisor

	Sand particles or mud on washed roots	QA/QC supervisor
Monitoring Action 3	Finger feel of moisture level in pressed cake	QA/QC supervisor
	Dirt on dewatering equipment.	QA/QC supervisor
	Dirt on sacks used for dewatering	QA/QC Supervisor
Monitoring Action 4	Sweetness or otherwise of cassava variety	QA/QC Supervisor
	Qualitative assessment of CNP level	QA/QC Supervisor
Monitoring Action 5	Ambient Temperature for sun-drying	QA/QC Supervisor
	Internal temperature of solar dryer	QA/QC Supervisor
	Internal temperature of mechanical dryer	QA/QC Supervisor
	Loading density of products in sun drying facility	QA/QC Supervisor
	Loading density of products in solar dryer	QA/QC Supervisor
	Loading of products in mechanical dryer	QA/QC Supervisor
	Drying time for sun-drying	QA/QC Supervisor
	Drying time for solar drying	QA/QC Supervisor
	Drying time for mechanical drying	QA/QC Supervisor
	Animal Droppings and dust on drying surfaces	QA/QC Supervisor
	Animal droppings and dust on drying materials	QA/QC Supervisor
	Presence or absence of pests, birds, domestic animals, reptiles etc., in drying area.	QA/QC Supervisor
Monitoring Action 6	Wholeness and integrity of packages	QA/QC Supervisor
	Presence or absence of weevils in packaged products.	QA/QC Supervisor
	Presence or absence of weevils in and around storeroom	QA/QC Supervisor

Handling Corrective Actions

Corrective Action Plan	Action needed to be taken	Personnel Responsible
Corrective Action 1	Rejection of unwanted variety or over-aged roots	Production Manager
	Redirection of roots supplied more than 8 hours after harvesting, for production of other fermented cassava products.	Production Manager
Corrective Action 2	Changing water for washing.	Production Supervisor
	Changing source of water	Plant Manager
	Alerting production staff to re-wash peeled roots.	Production Manager
Corrective Action 3	Instructions to repeat dewatering process.	Production Manager
	Re-cleaning of dewatering equipment and sacks.	QA/QC Manager
Corrective Action 4	Instructions for re-directing high CNP cassava originally intended for chipping to be grated instead.	Production Manager

Corrective Action 5	Re-drying of products	Production Manager
	Instructions to redirect products for non-food applications.	Production Manager
	Prevention of pests, birds and other animals.	QA/QC Manager
	Instructions for contaminated products to be re-directed for animal feed or other non-food application.	Production Manager
Corrective Action 6	Instructions for damaged packages to be re-packaged for non-food applications.	Production Manager
	Instructions for re-sifting and re-drying of defective products in mechanical dryer.	Production Manager
	Instructions for repackaging of mechanically dried defective products for immediate supply to non-food end-users.	Plant Manager

APPENDIX V: PICRATE SCORING COLOUR CHART

9 8 7 6 5 4 3 2 1

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ISBN 978 - 131 - 282 - 3