

CODE OF PRACTICE FOR THE REDUCTION OF HYDROCYANIC ACID (HCN) IN CASSAVA AND CASSAVA PRODUCTS

(CAC/RCP 73-2013)

INTRODUCTION

1. Hydrogen cyanide is a volatile compound which evaporates rapidly in the air at temperatures over 28°C and dissolves rapidly in water. It may easily be lost during transport, storage and analysis of samples.
2. Hydrogen cyanide is a chemical compound that can be released from cyanogenic glycosides that are natural constituents of some plants such as: bitter almonds, sorghum, cassava, lima beans, stone fruits and bamboo shoots. Therefore reduction and removal measures of hydrogen cyanide (HCN) should focus on the precursor i.e. cyanogenic glycosides and cyanohydrins.
3. Hydrogen cyanide may be toxic to humans and animals, and the severity of the toxicity depends on the quantity consumed.
4. Cassava is an important staple crop containing cyanogenic glycosides. The cassava plants including the roots also contain the enzyme linamarase that breaks down the cyanogenic glycosides to release cyanohydrin, which dissociates at low levels of acidity to produce hydrogen cyanide. The extent of the breakdown of the cyanogenic glycosides and the eventual release of hydrogen cyanide depends on the amount of linamarase present in the cassava tissue; the extent of the disruption of the tissue, the acidity of the product, and the heat treatment are key factors in determining the concentration of residual cyanogens in cassava products. It is evident that high concentrations of cyanogenic glycosides may result in higher concentrations of hydrogen cyanide.

SCOPE

5. This Code of Practice intends to provide national and local authorities, manufacturers and other relevant bodies with guidance on how to produce cassava products with safe concentrations of residual cyanogenic compounds.

GENERAL REMARKS

6. This Code outlines measures that have been proven to prevent and/or reduce concentrations of hydrogen cyanide in cassava products. When applying the code for cassava processing methods should be carefully chosen from the viewpoint of benefit and feasibility. In addition, these should be implemented in accordance with the relevant national and international legislation and standards.
7. It is recognized that reasonable application of technological measures such as Good Manufacturing Practices (GMP), can be taken to prevent or reduce significantly the concentrations of hydrogen cyanide in cassava products.

MEASURES TO REDUCE THE PRECUSOR OF HYDROGEN CYANIDE

8. The potential cyanide content in cassava varies with the variety of cassava, the environmental conditions in which it is grown (e.g. drought) and time of harvest.
9. Varieties with low cyanide content have been developed and might be useful in reducing occurrence of hydrogen cyanide in cultivated cassava. Where bitter cassava varieties are used then adequate post harvest processing is essential.
10. Harvesting should be done at the appropriate time because studies have shown increased cyanide in late harvested cassava.

TYPICAL PRODUCTION PROCESS

11. Processing is effective in reducing cyanogenic compound content to minimum concentrations when done appropriately. Inadequate or poor processing as sometimes occurs during famine and periods of social stress or the rush to market can lead to high residues of HCN in the final product.
12. The production process for cassava products varies with the intended product. Some examples of cassava products include gari, fufu, cassava flour, cassava starch(tapioca), cassava chips etc. figures 1-8 illustrate the steps in the production processes of some cassava products.

GARI PRODUCTION

13. For gari, a fermented, granular cassava food product; the production process involves selection of cassava tubers, peeling, washing, grating, dewatering and fermentation, sieving, frying, cooling/drying, sieving and packaging. The process typically follows the steps listed below.
 - a. **Selection:** Fresh and wholesome cassava tubers are selected from the lots for processing
 - b. **Peeling:** Peeling is carried out to remove the outer inedible parts of the roots; these are known to contain most of the cyanogenic glycosides.
 - c. **Washing:** This is done to remove dirt and other contaminants. It is advisable to also wash before peeling to reduce the microbial load.
 - d. **Grating the cassava roots:** Grating is done either manually by rubbing peeled and washed cassava roots against a metal sheet with perforations made with a nail or mechanically using a grater. During grating, the cyanogenic glycosides are hydrolyzed by the enzyme, linamarase.
 - e. **Dewatering and Fermentation:**
 - i. In traditional fermentation, fermentation and dewatering are carried out at the same time by packing the grated cassava in sacks and pressed under pressure by putting weights on the sacks or using hydraulic press.
 - ii. Fermentation is done to develop the taste of the gari. The fermentation period could be between 12 – 24 hours, resulting in the production of gari with an almost bland taste and high starch content, or could vary from 48 – 164 hours resulting in the production of gari with sour taste and lower starch content.
 - iii. During fermentation, especially within 12 – 24 hours, cyanohydrins, which is the intermediate product of the breakdown of the cyanogenic glycoside rapidly dissociates to produce hydrogen cyanide which is volatile and easily lost. However as fermentation is allowed to progress beyond this time, the cassava mash becomes acidic (this is responsible for the sour taste) and the acidity retards the spontaneous dissociation of the cyanohydrins and fixes them in the food. These cyanohydrins slowly dissociate under normal storage conditions; the rate of dissociation is increased by contact with alkalis and/or heat.
 - f. **Sieving:** Sieving is done to remove the large lumps and fibres and also to obtain a homogeneous product for a more uniform roasting of individual particles during the roasting operation.
 - g. **Roasting:** Should be properly done by placing the sieved fermented grated cassava on a pan stirring until it becomes dry. Palm oil may be added during roasting as is done in some parts of Nigeria. Roasting has an effect on the amount of residual cyanogenic compounds in the final product and the shelf life/storability of the product.

FUFU AND FUFU POWDER PRODUCTION

14. The production of fufu, and fufu flour involves: Peeling of the roots, washing, cutting, fermentation, mashing and sieving/pounding, dewatering and drying. The process follows the steps listed below.
- a. Selection of fresh whole cassava roots
 - b. **Peeling:** peeling is carried out to remove the outer inedible part which is known to contain most of the cyanogenic glycosides.
 - c. **Washing:** the peeled cassava roots are washed with water.
 - d. **Cutting:** the washed cassava roots are cut into small pieces. These will facilitate the fermentation process.
 - e. **Fermentation:** Fermentation is carried out in tanks or other suitable fermentation vessels for 3-4 days.
 - f. **Mashing/Pounding:** The fermented cassava pieces are mashed and passed through a sieve, and when the roots are not soft enough to be mashed by hand, they are pounded or passed through a grater before the fibres are removed by adding water to the mash and filtering.
 - g. **Dewatering:** Excess water is removed from the mash by packing the mash into a woven polyethylene sack and pressing with weights or a hydraulic press to produce fufu.
 - h. **Drying:** Instant fufu flour is produced by either sun drying of the dewatered mash or artificially using a mechanical dryer.

DRIED CASSAVA CHIPS

15. Cassava chips are dried granules derived from clean, fresh cassava. The production of dried cassava chips involves peeling, slicing or chipping, and drying.
- a. **Peeling:** Peeling is carried out to remove the outer inedible parts of the root; these are known to contain most of the toxic cyanogenic glycosides.
 - b. **Chipping/slicing:** The objective of chipping is to expose the maximum surface of the cassava roots and encourage rapid drying. Best drying in terms of quickness and quality of the end product is achieved when the peeled cassava is thinly sliced - less than 10 mm thick.
 - c. **Drying:** Sun-drying of cassava chips is carried out on any convenient flat surface, the objective is to produce dry cassava chips which are clean, having white colour, free from extraneous matter and can be safely stored for long periods.

OTHER CASSAVA PRODUCTS

16. Cassava chips used as a snack food may be made from extruded flour or from dried cassava chips.
- a. **Peeling:** Peeling is carried out to remove the outer inedible parts of the root; these are known to contain most of the cyanogenic glycosides.
 - b. **Slicing:** The objective of slicing is to expose the maximum surface of the cassava roots and encourage a rapid drying. Best drying in terms of quickness and quality of the end product is achieved when the peeled cassava is thinly sliced less than 2 mm
 - c. **Frying, heating food up to temperatures above 180°C:** The surface dries out, sealing the water content inside.

17. Cassava starch is one of the most commonly used starches in food manufacturing and functions as a thickener, emulsifier or confectionery ingredient. The production of cassava starch involves selection, peeling, washing, grating, starch separation and drying.
 - a. **Selection:** cassava roots are harvested and selected for starch extraction
 - b. **Peeling:** peeling is carried out to remove the outer inedible part which is known to contain most of the cyanogenic glycosides
 - c. **Washing:** the peeled cassava roots are washed with water
 - d. **Grating:** after peeling and washing, the roots are grated to release the starch granules and then they are added with water to extract the starch.
 - e. **Starch separation:** Starch is separated from the pulp and water by sedimentation or by means of a centrifugation.
 - f. **Drying:** starch is sun-dried or an artificial dryer is used before milling and sieving
18. There are several other cassava based food products such as Lafun, an unfermented cassava flour; Attieke - steamed fermented cassava granules; Chikwangue, Bila - a soaked cassava Fijian food; Farinha - a roasted cassava product produced in Brazil; Bikedì - a traditional fermented cassava root food; Ntobambodi - a semi solid fermented cassava leaves soup both consumed in Congo; and Bammy – a baked/ fried cassava cake consumed in Jamaica. Their methods of preparation are similar to the foregoing process steps although in some instances may differ; examples are soaking, wrapping of tubers, etc.

PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES

19. Cultivars of cassava should be carefully selected and planted
20. Conditions of severe drought during planting should be avoided or minimized through cultivation practices such as wetting, and conditions leading to high moisture content should also be avoided.

RECOMMENDED PRACTICES BASED ON GOOD MANUFACTURING PROCESSES

21. Raw Materials Selection

Selection of cassava Roots: Cassava roots for the preparation of cassava products should be processed as soon as practicable after harvest.

22. The cassava selected from the lots should be of high quality and incidences of bruises, mechanical damage, should be minimised. Spoiled and woody cassava should be avoided.

PREPARATION OF CASSAVA PRODUCTS

23. Process flow charts for preparation of different cassava products are given in figures 1-7. However the following, not in any particular order, are recommended practices for each of the unit operations in the flow charts of the products.
24. **Peeling:** This should be done with clean stainless knives. Ensure that the peels including rinds (inedible part) are completely removed; they are known to contain very high concentrations of cyanogenic glycosides which can be toxic.
25. **Washing:** Wash the peeled roots in water at least twice to remove pieces of the peel, sand and other dirt.

26. **Grating:** Grating should be properly done using stainless steel equipment to rupture the cassava tissue for a fast breakdown of cyanogenic glycosides.
27. **Soaking:** Soaking in water is often done for one to three (1-3) days, before or after the chipping operation during which some fermentation takes place that gives the chips the sour flavour favoured by some consumers. It also allows hydrogen cyanide to diffuse out making the product safer for human consumption. The National Root Crop Research Institute in Nigeria suggested that optimal hydrocyanic acid reduction can be achieved through a combination of 15 minute soaking and 2 minute blanching of cassava chips.
28. **Fermenting:** Put cassava mash in a clean sack and tie. Allow to stand in a fermenting trough for 2-3 days. Arrange the sacks in such a way that there is no contact with sand or dirt that can contaminate the mash. Allow free seeping of water from the sacks. Fermenting should not be less than 2 days to ensure adequate cyanide detoxification. The practice of processing cassava roots which have stored overnight without fermenting the mash is not encouraged because the gari produced by this method invariably contains high concentrations of cyanide.
29. **Pressing:** At the end of the fermentation period the mash in the sacks is pressed to remove as much moisture as possible. Pressing is completed when water is no longer dripping from the sacks. If dewatering is not complete, there would be lumps during roasting which reduce the quality and yield of gari.
30. **Cake breaking / Sifting or Sieving:** The cassava mash cake produced by the dewatering/pressing process is disintegrated using clean hands followed by sifting/sieving with a non-rusting sifter into a clean basin. A sifter made of stainless steel material is preferable.
31. **Roasting:** Roast and stir constantly in a large shallow cast-iron pan over fire, with a piece of gourd or wooden paddle until the product, gari in this instance, is dried.
32. **Cooling:** Collect the roasted product in a clean basin and spread on a raised platform lined with clean polythene material or white cloth to cool to room temperature.
33. **Packaging:** Packaging of processed cassava products should be in clean, insect-and moisture-proof materials that guarantee the wholesomeness of the product and retention of its nutritional, physical and sensory qualities. The packaging material should not impart any toxic substance or undesirable odour/flavour to the cassava product.
34. **Chipping:** Chipping of cassava should be done thinly 10 mm for efficient, fast and adequate drying.
35. **Drying:** should be done in a hygienic and dust free environment where animals and birds cannot get to it.
36. **Storage:** Storage of finished product or dried intermediate product should be in a cool, dry, well-ventilated, insect-and rodent-free store/enclosure.
37. **Cooking:** Only Cassava known to have low cyanide should be used for direct cooking and consumption i.e. the sweet type, because cyanogenic glycosides are heat stable.

GENERAL RECOMMENDATIONS

38. National, state and local governments as well as non-governmental organizations (NGOs, commercial associations and cooperatives) should be involved in promoting effective cassava cultivation with the introduction of low cyanide, high yielding and well-adapted varieties of cassava and processing methods as a means to ensure maximum reduction of residual cyanogens in cassava food products.
39. Campaigns for introduction of other staples, vegetables, pulses and fruits to decrease the daily cyanide intake and broaden the diet could also result in lower consumption of cyanogenic glycosides.

40. Non-industrial, small-scale producers of cassava and cassava products should have access to materials with information on the specific recommendations based on Good Manufacturing Practice and guidance on methods for reducing residual cyanogens in cassava products.
41. Food Safety Authorities and Public Health Monitoring bodies may consider introducing scientific kits such as picrate kits to monitor cyanide concentrations in cassava products the point of use and urinary thiocyanate concentrations in the population.

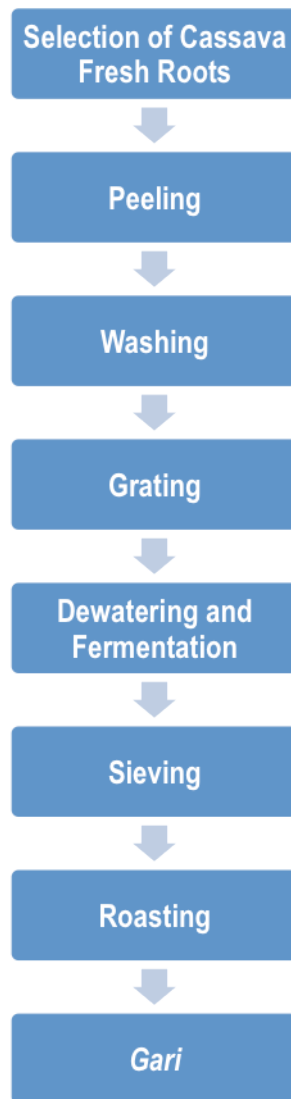


Figure 1: Flow chart for production of Gari

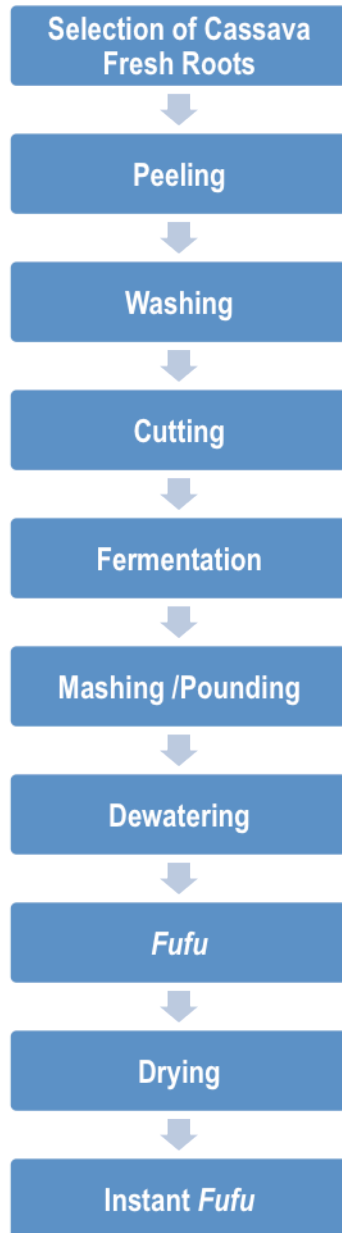


Figure 2: Flow chart for production of Fufu/Instant fufu

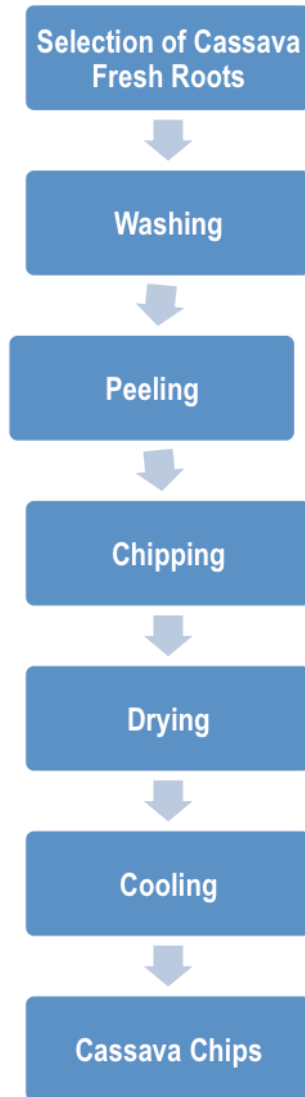


Figure 3: Flowchart for production of Cassava chips

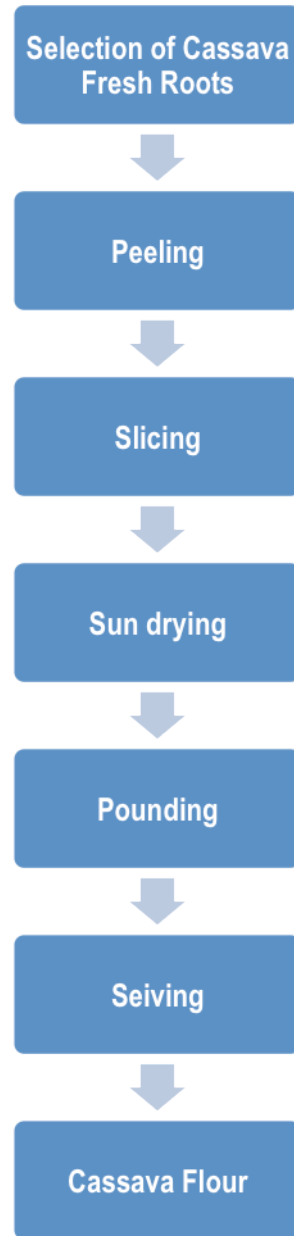


Figure 4: Flowchart for Production of Unfermented Cassava Flour

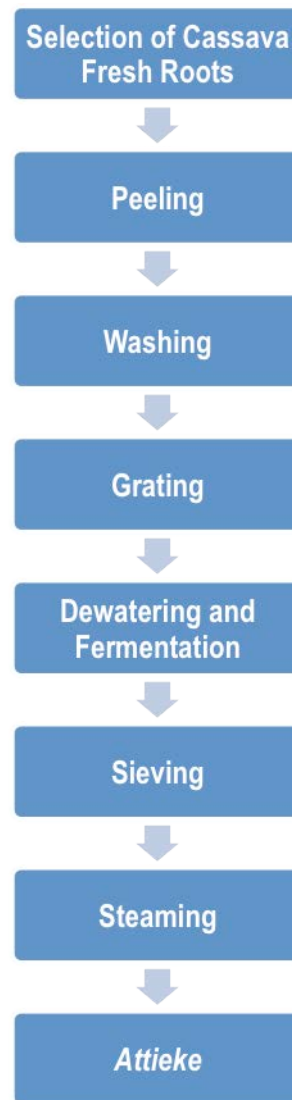


Figure 5: Flowchart for production of Attieke

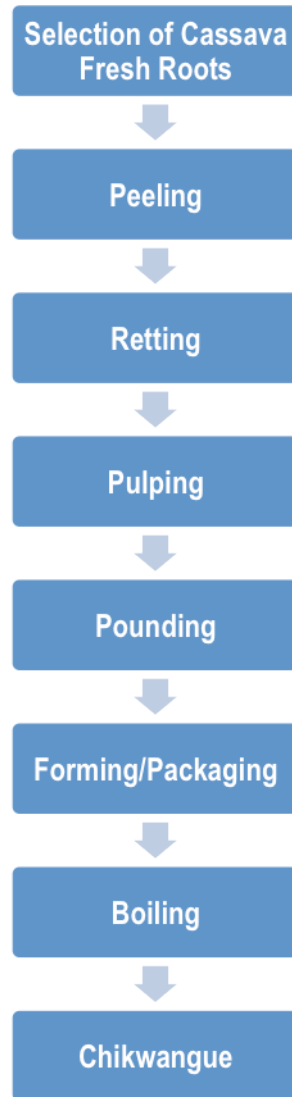


Figure 6: Flowchart for Production of Chikwangue

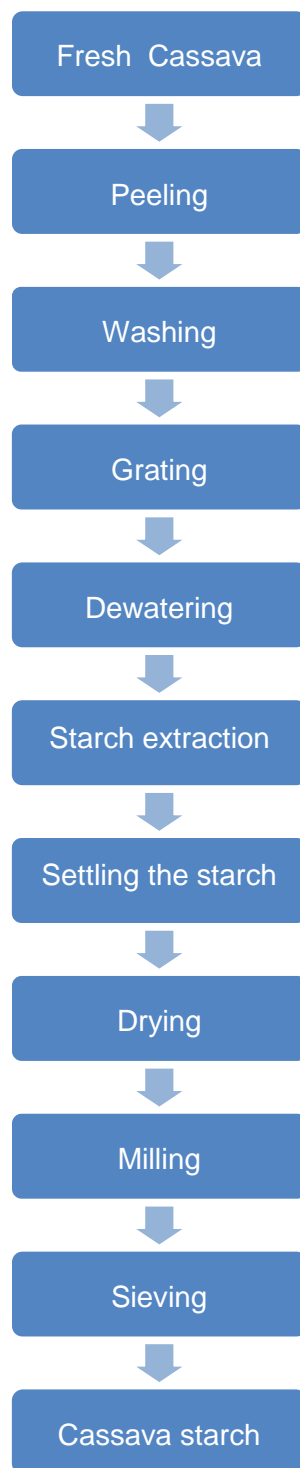


Figure 7: Flow chart for the preparation of Cassava Starch

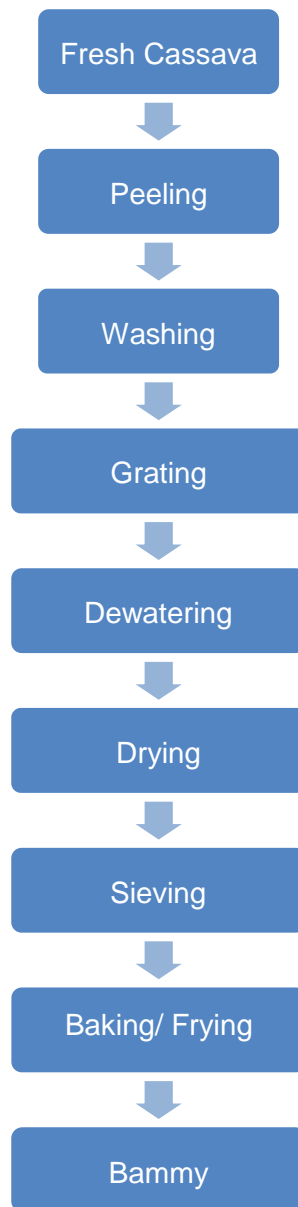


Figure 8: Flow chart for the preparation of Bammy