Code of Practice for the Reduction of Hydrocyanic Acid (HCN) in Cassava and Cassava Products
Foreword

This Philippine National Standard (PNS) was developed in response to the development of the Codex Code of Practice (COP) for the Reduction of Hydrocyanic Acid (HCN) in Cassava and Cassava Products (CAC/RCP 73-2013), which was adopted in 2013. The PNS is therefore, an adoption of this Codex COP with modifications to suit the local production practices in the Philippines.

A Technical Working Group (TWG) was created through Special Order No. 105 Series of 2014 to develop the draft COP for the Reduction of Hydrocyanic Acid (HCN) in Cassava and Cassava Products. The TWG represented the relevant agencies of the Department of Agriculture (DA), Department of Health (DOH), Department of Science and Technology (DOST), and the academe. Public consultations were conducted in Regions V, VII, X and the National Capital Region (NCR), which represented the major hubs of cassava production and trade. Comments and recommendations were solicited from the relevant government agencies, academe, and private sector and non-government organizations. Therefore, this COP is the final output of the public-private sector collaboration between, and among the TWG and the relevant stakeholders, who participated in the public consultations.
I. INTRODUCTION

1. Hydrogen cyanide or hydrocyanic acid (HCN) is a volatile compound which evaporates at temperatures over 28°C and dissolves rapidly in water. It may easily be lost during transport, storage and analysis of samples.

2. HCN 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 HCN should focus on the precursor i.e. cyanogenic glycosides and cyanohydrins.

3. HCN may be toxic to humans and animals, and the severity of the toxicity depends on the quantity consumed. In humans, the symptoms of acute cyanide intoxication from inadequately prepared cassava can include: rapid respiration, drop in blood pressure, rapid pulse, dizziness, headache, stomach pains, vomiting, diarrhea, mental confusion, twitching and convulsions. In animals, it affects the reproductive organs including birth rates and an increase number of neonatal deaths, impaired thyroid function, and behavioral effects including increasing ambivalence and slower response time. Death due to cyanide poisoning can occur when the cyanide limit exceeds the limit of what an individual is able to detoxify.

4. Cassava (Manihot esculenta Crantz) is a woody shrub extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy enlarged root. Cassava is a major source of carbohydrates in the human diet. However, one of the limiting characteristic of cassava used for food and feed is the cyanogenic glycosides content of its roots and leaves. The amount of the cyanogenic glycosides varies depending on the cultivar and growing conditions. 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 HCN. The extent of the breakdown of the cyanogenic glycosides (and the eventual release of HCN depending 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 HCN.

5. The CAC through the Joint Food and Agriculture Organization (FAO) – World Health Organization (WHO) Expert Committee on Food Additives (JECFA), previously developed Maximum Levels (MLs) for HCN in Sweet Cassava, Bitter Cassava, Edible Cassava Flour and Gari (a product obtained from processing cassava roots). These are the following:
- Sweet Cassava - less than 50mg/kg of HCN
- Bitter Cassava (must not be eaten raw) - more than 50mg/kg of HCN
- Edible Cassava Flour - must not exceed 10mg/kg HCN
- Gari - must not exceed 2mg/kg as free HCN

6. In the Philippines, cassava is popularly known as balinghoy or kamoteng-kahoy, and is being advocated as an alternative staple to rice under the Department of Agriculture (DA) - Food Self-Sufficiency Program (FSSP). The DA, through the Bureau of Agriculture and Fisheries Standards (BAFS), developed two (2) Philippine National Standards (PNS) related to cassava which are harmonized with the Codex standards, namely:

- PNS/BAFPS 29:2009 Dried cassava chips and granules; and

7. This Code outlines measures that have been proven to prevent and/or reduce concentrations of HCN in cassava and its products. When applying this Code for cassava processing, methods should be carefully chosen from the viewpoint of benefit and feasibility. In addition, this should be implemented in accordance with the relevant national and international legislations.

8. It is recognized that reasonable application of technological measures such as Good Manufacturing Practices (GMP), can be taken as an intervention to remove or reduce significantly the concentrations of HCN in cassava and its products.

II. SCOPE

9. This COP intends to provide national and local authorities, producers, traders, processors and other relevant stakeholders with guidance on how to produce and process cassava roots and its products such as grates, chips, granules, flour and starch with safe concentrations of residual cyanogenic compounds.

III. DEFINITION

For the purpose of this Code, the following terms are operationally defined:

cassava - (Manihotes sculetana Crantz) also called manioc, yuca, balinghoy, mogo, mandioca, kamoteng-kahoy, tapioca-root, and manioc root: a woody shrub extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy, enlarged root. The following are the different cassava types/forms:

bitter cassava - variety with high concentration of HCN, which normally more than 50 mg/kg HCN by fresh weight (e.g. Sutan 2 & Mcol 1684).

sweet cassava
variety with low concentration of HCN, which normally less than 50 mg/kg HCN by fresh weight (e.g. Lakan 1 & Rayong 5).
cassava products - refer to cassava chips, granules, grates, flour, starch, adhesives and other industrial and pharmaceutical products.

chilling - refers to the process of maintaining the product at temperatures not exceeding 4 °C in any part of the product.

clean water - water that does not compromise food safety in the circumstances of its use.

cooling - refers to the process where the product is cooled at ambient or room temperature (30°C to 35°C).

cyanogenic glycosides - are secondary metabolites that are found in various plant tissues and produce HCN upon hydrolysis, which may be toxic to humans and animals, the severity of the toxicity depends on the quantity consumed.

drying - removal or reduction of moisture content (MC) of cassava products through solar, oven or mechanical dryer to prolong the shelf life of cassava products.

freezing - refers to the process of maintaining the product at a temperature equal to or below – 18 °C in any part of the product.

fresh cassava - refers to roots that have been harvested, unprocessed, and stored prior to processing without any sign of deterioration.

hydrogen cyanide or hydrocyanic acid (HCN) - refers to total hydrocyanic acid which maybe enzymatically released from a cyanogenic glycoside as well as any free or unbound HCN in cassava, expressed in milligrams of HCN per kilogram of fresh cassava and its products (mg/kg).

potable water - water which meets the quality standards of drinking water such as described in the WHO Guidelines for Drinking Water Quality.

IV. Typical Cassava Production Processes

10. Processing cassava for food and feed uses is effective in reducing cyanogenic compound content to minimum concentrations, when done appropriately. Inadequate or improper processing sometimes can lead to high residues of HCN in the final product.

11. The production process for cassava products varies with the intended product. Some examples include cassava grates, chips, granules, flour, starch, and other industrial and pharmaceutical products. Figures 1 – 5, illustrate the steps in the production processes of some cassava products.

Grated Cassava

12. For grated cassava, the production process involves selection, cleaning, peeling, washing, grating, dewatering, cooling/chilling/freezing, drying, sieving
(depending on use) and packing. The process typically follows the steps listed below:

a. **Selection**: Select the fresh and healthy cassava roots from the lots for processing of cassava. Preferably the selected cassava roots are sweet type and 7 - 9 months old.

b. **Cleaning**: This is done manually to remove the soil and other foreign materials in the skin so as not to contaminate the produce.

c. **Peeling**: This is done manually with clean stainless knives or mechanically using stainless steel tool such as peeler. It is advisable to wash the cassava with clean water before peeling to reduce the microbial load. Ensure that the peels including rinds (inedible part) are completely removed. Peels (including rinds) are known to contain very high concentrations of cyanogenic glycosides, which can be toxic. The peel of bitter cassava variety was shown to contain an average of 650 ppm and the pulp of 310 ppm total cyanide. For sweet varieties, total cyanide was 200 ppm and 38 ppm for peel and pulp, respectively. Peeling therefore, can effectively reduce the cyanide content by at least 50%.

d. **Washing**: This is done manually using clean water or mechanically using stainless steel equipment such as washer to remove the dirt, and other contaminants and reduce the microbial load.

e. **Grating**: This is done manually by rubbing the peeled cassava roots against the stainless sheet with perforations or mechanically using stainless steel equipment such as grater (please refers to Annex 1). During grating, the cyanogenic glycosides are hydrolyzed by the enzyme, linamarase.

f. **Dewatering**: This is done manually by placing the grated cassava in food grade sacks or any clean suitable food grade container and pressed or squeezed by putting weights on the container or mechanically using stainless steel equipment such as hydraulic press (please refer to Annex 2).

g. **Cooling/Chilling/Freezing**: This is done to prolong the shelf life of grated cassava

h. **Drying**: This is done through solardrying by drying the grated cassava in any clean suitable surface or using hygienic mechanical drying equipment (please refer to Annex 3) in a dust-free environment, protected from animals like insects, birds, and other contaminants. Drying is done to reduce the MC of grated cassava to at most 14% MC. Dried grated cassava should be clean, free from extraneous matter, and can be safely stored for a long period.

i. **Sieving/Sifting**: This is done manually by straining the grated cassava using a clean siever to remove the large lumps and fibers to obtain a homogeneous product or mechanically using stainless steel equipment such as sifter.
j. **Packing:** This is done manually by filling in containers, which will safeguard the hygienic, nutritional, technological and organoleptic qualities of the product or mechanically using stainless steel packing machine. The containers, including the packaging material, shall be made of substances, which are safe and suitable for the intended product. They should not impart any toxic substance or undesirable odor, flavor to the product. When the product is packaged in sacks, these must be clean, sturdy and strongly sewn or sealed.

k. **Labeling:** In addition to the requirements of the Codex General Standard for the Labeling of Prepackaged Foods (CODEX STAN 1-1985), the following specific provisions apply: a.) Nature of Produce – Each package, shall be labeled as to the name of the product and type (sweet or bitter) or may be labeled as to the name of variety and b.) Non-Retail Containers – Information for non-retail containers, shall be given on the container or in accompanying documents except that the name of the product, lot identification, and the name and address of the manufacturer or packer, shall appear on the container. However, lot identification and the name and address of the manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

l. **Storing:** Storing of grated cassava should be at room temperature, dry, well-ventilated, and insect-and rodent-free store/enclosure.

**Dried Cassava Chips and Granules**

13. Dried cassava chips and granules are derived from clean, fresh, and healthy cassava. The production of dried cassava chips and granules involve selection, cleaning, chipping/slicing, granulating, drying, packing, labeling and storing.

a. **Selection:** Select the fresh and healthy cassava roots from the lots for processing of cassava. Preferably the selected cassava roots are sweet type and 8 - 12 months old.

b. **Cleaning:** This is done manually to remove the soil and other foreign materials in the skin so as not to contaminate the produce.

c. **Chipping/slicing:** This is done manually using clean stainless knives or mechanically stainless steel equipment such as chipper. Chipping/slicing of cassava root should be done thinly i.e. less than 10 mm thick for efficient, fast and adequate drying.

d. **Granulating:** This is done manually by continuous circular hand stirring movement or mechanically using stainless steel equipment such as granulator (please refer to Annex 4) to produce round and smooth particles.

e. **Drying:** This is done through solar drying by drying the cassava chips and granules in any suitable clean surface or using hygienic mechanical drying equipment in a dust-free environment, protected from animals like insects,
birds, and other contaminants. Drying is done to reduce the MC of chips and granules to at most 14% MC. Dried cassava chips and granules should be clean, having a white color, free from extraneous matter, and can be safely stored for a long period. Total cyanide content of cassava chips could be decreased by only 10-30%.

f. **Packing:** This is done manually by filling in containers which will safeguard the hygienic, nutritional, technological and organoleptic qualities of the product or mechanically using stainless steel packing machine. The containers, including the packaging material, shall be made of substances, which are safe and suitable for the intended product. They should not impart any toxic substance or undesirable odor, flavor to the product. When the product is packaged in sacks, these must be clean, sturdy and strongly sewn or sealed.

g. **Labeling:** In addition to the requirements of the Codex General Standard for the Labeling of Prepackaged Foods (CODEX STAN 1-1985), the following specific provisions apply: a.) **Nature of Produce** – Each package shall be labeled as to the name of the product and type (sweet or bitter) or may be labeled as to the name of variety and b.) **Non-Retail Containers** – Information for non-retail containers, shall be given on the container or in accompanying documents except that the name of the product, lot identification and the name and address of the manufacturer or packer shall appear on the container. However, lot identification and the name and address of the manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

h. **Storing:** Storing of cassava chips and granules should be at room temperature, dry, well-ventilated, and insect-and rodent-free store/enclosure.

**Cassava Chips**

14. Dried cassava chips used as snack food can be made from extruded flour or from dried cassava chips. The production process involves selection, cleaning, peeling, slicing, frying/heating, packing, labeling and storing.

a. **Selection:** Select the fresh and healthy cassava roots from the lots for processing of cassava. Preferably the selected cassava roots are sweet type and 8 - 12 months old.

b. **Cleaning:** This is done manually to remove the soil and other foreign materials in the skin so as not to contaminate the produce.

c. **Peeling:** This is done manually with clean stainless knives or mechanically using stainless steel tool such as peeler. It is advisable to wash the cassava with clean water before peeling to reduce the microbial load. Ensure that the peels, including rinds (inedible part) are completely removed. Peels (including rinds) are known to contain very high concentrations of cyanogenic glycosides, which can be toxic. The peel of bitter cassava variety was shown to contain an average of 650 ppm and the pulp of 310 ppm total cyanide. For
sweet varieties, total cyanide was 200 ppm and 38 ppm for peel and pulp, respectively. Peeling therefore, can effectively reduce the cyanide content by at least 50%.

d. **Chipping/Slicing:** This is done manually using clean stainless knives or mechanically stainless steel equipment such as chipper. Chipping/slicing of cassava root should be done thinly i.e. less than 2 mm thick for efficient, fast and adequate cooking.

e. **Frying or Heating of sliced cassava chips up to temperatures above 180°C:** The surface dries out, sealing the water content inside.

f. **Packing:** This is done manually by filling in containers which will safeguard the hygienic, nutritional, technological, and organoleptic qualities of the product or mechanically using stainless steel packing machine. The containers, including the packaging material shall be made of substances, which are safe and suitable for the intended product. They should not impart any toxic substance or undesirable odor, flavor to the product. When the product is packaged in sacks, these must be clean, sturdy and strongly sewn or sealed.

g. **Labeling:** In addition to the requirements of the Codex General Standard for the Labeling of Prepackaged Foods (CODEX STAN 1-1985), the following specific provisions apply: a.) Nature of Produce – Each package, shall be labeled as to the name of the product and type (sweet or bitter) or may be labeled as to the name of variety and b.) Non-Retail Containers – Information for non-retail containers, shall be given on the container or in accompanying documents except that the name of the product, lot identification and the name and address of the manufacturer or packer, shall appear on the container. However, lot identification and the name and address of the manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

h. **Storing:** Storing of cassava chips should be at room temperature, dry, well-ventilated, and insect-and rodent-free store/enclosure.

**Cassava Flour**

15. Cassava flour can be used in various food applications.

a. **Selection:** Select the fresh and healthy cassava roots from the lots for processing of cassava. Preferably the selected cassava roots are sweet type and 8 - 12 months old.

b. **Cleaning:** This is done manually to remove the soil and other foreign materials in the skin so as not to contaminate the produce.

c. **Peeling:** This is done manually with clean stainless knives or mechanically using stainless steel tool such as peeler. It is advisable to wash the cassava with clean water before peeling to reduce the microbial load. Ensure that the
peels, including rinds (inedible part) are completely removed. Peels (including rinds) are known to contain very high concentrations of cyanogenic glycosides, which can be toxic. The peel of bitter cassava variety was shown to contain an average of 650 ppm and the pulp of 310 ppm total cyanide. For sweet varieties, total cyanide was 200 ppm and 38 ppm for peel and pulp, respectively. Peeling therefore, can effectively reduce the cyanide content by at least 50%.

d. Washing: This is done manually using clean water or mechanically using stainless steel equipment, such as washer to remove the dirt and other contaminants and reduce the microbial load.

e. Grating: This is done manually by rubbing the peeled cassava roots against the stainless sheet with perforations or mechanically using stainless steel equipment such as grater. During grating, the cyanogenic glycosides are hydrolyzed by the enzyme, linamarase.

f. Dewatering: This is done manually by placing the grated cassava in food grade sacks or any clean suitable food grade container and pressed or squeezed by putting weights on the container or mechanically using stainless steel equipment such as hydraulic press.

g. Drying: This is done through solar drying by drying the grated cassava in any suitable clean surface or using hygienic mechanical drying equipment in a dust-free environment, protected from animals like insects, birds, and other contaminants. Drying is done to reduce the MC of cassava flour to atmost 14%.

h. Milling/ Pulverizing: This is done mechanically using stainless steel equipment such as miller to produce approximately 80 mesh of the final form.

i. Packing: This is done manually by filling in containers which will safeguard the hygienic, nutritional, technological and organoleptic qualities of the product or mechanically using stainless steel packing machine. The containers, including the packaging material shall be made of substances, which are safe and suitable for the intended product. They should not impart any toxic substance or undesirable odor, flavor to the product. When the product is packaged in sacks, these must be clean, sturdy and strongly sewn or sealed.

j. Labeling: In addition to the requirements of the Codex General Standard for the Labeling of Prepackaged Foods (CODEX STAN 1-1985), the following specific provisions apply: a.) Nature of Produce – Each package shall be labeled as to the name of the product and type (sweet or bitter) or may be labeled as to the name of variety and b.) Non-Retail Containers – Information for non-retail containers shall be given on the container or in accompanying documents except that the name of the product, lot identification, and the name and address of the manufacturer or packer, shall appear on the container. However, lot identification and the name and address of the
manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

k. Storing: Storing of cassava flour should be at room temperature, dry, well-ventilated, and insect-and rodent-free store/enclosure.

Cassava Starch

16. Cassava starch is commonly used in food manufacturing as a thickener, emulsifier and can also be used as raw materials of glues, plywood, and papers.

a. Selection: Select the fresh and healthy cassava roots from the lots for processing of cassava. Preferably the selected cassava roots are sweet type and 8 - 12 months old.

b. Cleaning: This is done manually to remove the soil and other foreign materials in the skin so as not to contaminate the produce.

c. Peeling: This is done manually using clean stainless knives or mechanically using stainless steel tool such as peeler to avoid the production of ferrocyanide, which gives bluish color to the starch if non-stainless tool is used. It is advisable to wash the cassava with clean water before peeling to reduce the microbial load. Ensure that the peels, including rinds (inedible part) are completely removed. Peels (including rinds) are known to contain very high concentrations of cyanogenic glycosides, which can be toxic. The peel of bitter cassava variety was shown to contain an average of 650 ppm and the pulp of 310 ppm total cyanide. For sweet varieties, total cyanide was 200 ppm and 38 ppm for peel and pulp, respectively. Peeling therefore, can effectively reduce the cyanide content by at least 50%.

d. Washing: This is done manually using clean water or mechanically using stainless steel equipment such as washer to remove the dirt and other contaminants and reduce the microbial load.

e. Rasping or Pulping: This is done manually by slicing the roots and then rasping, grating or crushing them, which tears the flesh into a fine pulp. The cell walls are torn up and the whole of the root is turned into mass in which the greater part, but not all, of the starch granules is released.

f. Screening and Washing: starch is separated from the cellulose fibers using the jet extractor or the continuous perforated-basket centrifuge and is done in three stages.

g. Settling and purification: This includes the whole series of operations for separating the pure starch from soluble contaminants.

h. Drying: This is done to remove free water from the sediment obtained in settling tanks on flour tables or from the concentrated slurries produced by
separators and purifiers. It can be accomplished through sun/oven/mechanical drying. The starch cake is led from the basket centrifuge by a warm conveyor to a pneumatic drier, where the final MC is reduced to at most 14%.

i. **Packing:** This is done manually by filling in containers which will safeguard the hygienic, nutritional, technological and organoleptic qualities of the product or mechanically using stainless steel packing machine. The containers, including the packaging material shall be made of substances, which are safe and suitable for the intended product. They should not impart any toxic substance or undesirable odor, flavor to the product. When the product is packaged in sacks, these must be clean, sturdy and strongly sewn or sealed.

j. **Labeling:** In addition to the requirements of the Codex General Standard for the Labeling of Prepackaged Foods (CODEX STAN 1-1985), the following specific provisions apply: a.) Nature of Produce – Each package shall be labeled as to the name of the product and type (sweet or bitter) or may be labeled as to the name of variety and b.) Non-Retail Containers – Information for non-retail containers shall be given on the container or in accompanying documents except that the name of the product, lot identification and the name and address of the manufacturer or packer shall appear on the container. However, lot identification and the name and address of the manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

k. **Storing:** Storing of cassava chips and granules should be at room temperature, dry, well-ventilated, and insect-and rodent-free store/enclosure.

V. **Recommended Practices based on Good Agricultural Practices (GAP)**

**Planting**

17. Cultivars of cassava should be carefully selected from reputable sources such as DA-Regional Outreach Station (ROS). Choose varieties with low cyanide content (please refer to PNS/BAFPS 119:2013). When bitter cassava varieties are used, adequate processing is essential to reduce the HCN content.

18. Plant cassava during the start of rainy season or when there is sufficient soil moisture condition.

**Harvesting**

19. Harvesting should be done at 7 - 9 months for fresh roots and 8 – 12 months for the production of starch. Late harvested cassava roots have shown to have increased in cyanide content.

**Raw Materials Selection**
20. Cassava roots for the preparation of cassava products should be processed as soon as possible after harvest.

21. The cassava selected from the lots should be of high quality and incidences of bruises, mechanical damage, should be minimized. Spoiled and woody cassava should be discarded.

VI. General Recommendations

22. National and local governments such as Department of Agriculture (DA), Department of Health (DOH), Department of Interior and Local Government (DILG), Department of Science and Technology (DOST), as well as Non-Governmental Organizations (NGOs), 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 cyanogen in cassava roots and its products.

23. Producers of cassava roots and its products should have access to materials with information on the specific recommendations based on GMP and guidance on methods for reducing residual cyanogen in cassava roots and its products.

24. The DA food safety regulatory agencies, particularly the Bureau of Plant Industry (BPI), may consider introducing scientific kits such as picrate kits or other validated analytical methods, to monitor cyanide concentrations in cassava roots and its products at the point of use.
Figure 1 - Flowchart for Processing of Grated Cassava
Figure 2 - Flowchart for Processing of Chips and Granules

Selection
Cleaning
Chipping/Slicing
Granulating
Drying
Packing
Labelling
Storing
Cassava Chips and Granules
Figure 3 - Flowchart for Dried Cassava Chips Used as Snack
Figure 4 - Flowchart for the Processing of Cassava Flour
Figure 5 - Flowchart for Processing of Cassava Starch
Annex 2

Cassava Grater
Annex 3

Cassava Presser
Annex 4

Cassava Mechanical Dryer
Annex 5

Cassava Granulator
The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Code of Practice for the Reduction of Hydrocyanic Acid (HCN) in Cassava and Cassava Products (CAC/RCP 73-2013).

Codex Standard for Bitter Cassava (Codex Stan 300-2010).

Codex Standard for Edible Cassava Flour (Codex Stan 176-1989).

Codex Standard for Gari (Codex Stan 151-1989).


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