**Lesson 3: Casava and Cyanide**

(at least 3 - 4 class periods)

Overview –

* Cassava is a valuable food source for many communities, it is crucial to raise awareness about the potential health risks associated with cyanide in cassava consumption. Education on proper processing techniques and varietal selection can play a vital role in mitigating these risks, ensuring that cassava remains a safe and nutritious staple in diverse diets.

Objectives – Students will:

* Examine the biology of cassava plants
* Analyze the role of cyanogenic glycosides in cassava,
* Examine the potential health risks associated with cyanide in cassava consumption.
* Investigate the presence of cyanogenic glycosides in cassava and analyze the efficacy of various processing methods in reducing cyanide levels, with the goal of understanding the potential health risks associated with cassava consumption and promoting safe processing practices.

Set up and Materials –

* [*Planning a Florida Heritage Garden* resource guide](https://floridaheritagefoods.com/wp-content/uploads/2023/10/SF-USDA-Harvest-ChartEAEO-2.pdf)
* Cassava plant samples or pictures
* Whiteboard and markers
* Projector and screen
* Computer and Internet access for research
* Printed articles or excerpts about cassava and cyanide
* Safety goggles

Instructions and Class Flow –

* Ask students if they are familiar with cassava and what they know about its cultivation and consumption.

Learning apprach 1: Cassava Biology (30 minutes): <https://floridaheritagefoods.com/latin-american-collection/cassava/>

* The teacher should present information about the biology of cassava, including its origin, growth conditions, and nutritional value. This can be done in lecture format, given as an article for students to annotate, or have students look up the information as a research assignment. Discuss the importance of cassava in providing a staple food source for many communities.
	+ “The roots and leaves of the cassava plant have been a staple food item in Latin America for thousands of years. Since it grows well in poor soil and hot climate, it was a reliable food crop in early Florida history, and it became a staple crop in many parts of Africa and Asia. A surge in immigration from Cuba and Latin America during the 20th century increased the popularity of cassava in Florida, and today many home gardeners throughout the state are growing cassava because it is nutritious, delicious and easy to grow.”
	+ “Cassava has been a staple food among indigenous populations in Latin America for thousands of years. It was cultivated in agricultural systems throughout the region prior to the arrival of Europeans. Its significance is highlighted in indigenous art throughout the continent. The Portuguese introduced cassava to Africa and Asia in the 16th century, and it quickly became an important food source. Although the Spanish cultivated cassava in Cuba for export, the plant did not gain immediate popularity in Florida until the mass immigration of Hispanic people in the 20th century. Today, cassava is becoming increasingly more popular due to the rise of Latin food stores and restaurants across the state.”
	+ “Cassava is the dominant source of carbohydrates among many indigenous communities in Latin America, and it is a key ingredient in many cuisines throughout the continent. The roots are roasted, baked, fried, or sauteed; mashed, grated, or ground and used in breads, crackers, and sweets like cake. The leaves are added to soups and stews. Both the roots and leaves must be carefully cooked to remove mild toxins, and preparation techniques vary across cultures. The introduction of cassava to tropical areas of Africa and Asia led to a proliferation of new ways to cook and consume cassava. Today, cassava is a common ingredient in West African cuisine in dishes such as mofongo. In Florida, cassava cuisine is influenced by African and Latin American roots, and the many flavor of cassava can be experienced throughout the state.”

Learnign approach 2: Cyanogenic Glycosides (30 minutes):

* Introduce the concept of cyanogenic glycosides and their role in cassava plants. Explain how these compounds can release toxic cyanide when the plant is damaged. Discuss the potential benefits of cyanogenic glycosides in protecting the plant from herbivores. This can be done in lecture format, given as an article for students to annotate, or have students look up the information as a research assignment.
	+ Cyanogenic Glycosides: Cyanogenic glycosides are natural compounds found in various plant species, including cassava (Manihot esculenta). These compounds serve as a defense mechanism against herbivores and pathogens. The most common cyanogenic glycoside in cassava is linamarin.
	+ Mechanism of Cyanide Release: Cyanogenic glycosides are relatively stable compounds within the intact plant cell. However, when the plant tissue is damaged, such as by chewing or cutting, an enzyme called linamarase comes into contact with cyanogenic glycosides. Linamarase catalyzes the hydrolysis of these glycosides, leading to the release of hydrogen cyanide (HCN).
	+ Cyanide Toxicity: Hydrogen cyanide is a highly toxic compound that interferes with cellular respiration by inhibiting the uptake of oxygen. The toxicity of cyanide poses a threat to herbivores and other pests that may consume cassava leaves or other parts.
	+ **Benefits of Cyanogenic Glycosides in Plant Defense:**
	+ Deterrence: The release of toxic cyanide acts as a deterrent to herbivores, discouraging them from feeding on cassava plants. This defense mechanism is especially crucial in regions where cassava is a primary food source, as it helps protect the crop from being overgrazed.
	+ Protection of Storage Organs: While cassava leaves contain cyanogenic glycosides, the concentration is often higher in other parts, such as the tuberous roots. This protects the energy storage organs of the plant from being consumed by pests.
	+ Selective Pressure: The presence of cyanogenic glycosides can create selective pressure on herbivores, favoring individuals that have evolved mechanisms to detoxify or tolerate cyanide. This, in turn, can lead to the co-evolution of plant defenses and herbivore adaptations.
	+ Facilitation of Mutualistic Relationships: Some researchers propose that cyanogenic glycosides may play a role in establishing mutualistic relationships between cassava plants and specific herbivores. Certain insects are known to detoxify cyanide and may be attracted to cassava as a result.
	+ Cassava Processing and Reduction of Cyanide: While cyanogenic glycosides provide a natural defense for cassava, they also pose a risk to human health if not properly processed before consumption. Traditional processing methods, such as soaking, fermenting, and cooking, can significantly reduce cyanide levels in cassava, making it safe for human consumption.
	+ Understanding the role of cyanogenic glycosides in cassava not only sheds light on the plant's natural defense mechanisms but also emphasizes the importance of culturally appropriate processing methods to make cassava a safe and valuable food source.

Learning Approach 3: Health Risks and Processing Techniques (40 minutes):

Explore the health risks associated with cyanide in cassava consumption. Discuss the symptoms of cyanide poisoning and its potential long-term effects.

**Health Risks Associated with Cyanide in Cassava Consumption:**

1. Cyanide Poisoning:

* Symptoms: Cyanide poisoning can occur if cassava is not properly processed before consumption. Initial symptoms of cyanide poisoning may include headaches, dizziness, nausea, and vomiting. In severe cases, it can progress to difficulty breathing, seizures, loss of consciousness, and death.

2. Acute Cyanide Poisoning:

* Symptoms: Acute cyanide poisoning can result from the ingestion of large amounts of cyanide in a short period. Symptoms may manifest rapidly and can include confusion, rapid breathing, cardiovascular collapse, and, in extreme cases, coma or death.
* Mechanism: Cyanide interferes with cellular respiration by inhibiting the activity of cytochrome c oxidase, an enzyme essential for the electron transport chain in mitochondria. This disrupts the production of adenosine triphosphate (ATP), leading to cellular dysfunction.

3. Chronic Exposure and Long-Term Effects:

* Neurological Effects: Prolonged exposure to low levels of cyanide, as may occur with regular consumption of improperly processed cassava, has been associated with neurological symptoms. These may include memory loss, difficulty concentrating, and peripheral neuropathy.
* Thyroid Dysfunction: Some studies suggest a potential link between chronic cyanide exposure and thyroid dysfunction. Cyanide may interfere with iodine uptake by the thyroid gland, affecting thyroid hormone production.

4. Cassava-Induced Spastic Paraparesis (CISP):

* Rare Neurological Syndrome: Chronic consumption of cassava with high cyanogenic glycoside content has been linked to a rare neurological syndrome known as Cassava-Induced Spastic Paraparesis (CISP). This condition is characterized by progressive spasticity and weakness in the legs.
* Association with Cyanide: CISP is thought to be associated with chronic exposure to low levels of cyanide from cassava consumption, though the exact mechanisms are not fully understood.

5. Prevention and Mitigation:

* Processing Techniques: Traditional processing methods, such as soaking, fermenting, and cooking, are effective in reducing cyanide levels in cassava. Adequate processing is essential for making cassava safe for consumption.
* Varietal Selection: Some cassava varieties have naturally lower levels of cyanogenic glycosides, contributing to reduced cyanide content in the edible portions. Selecting low-cyanide varieties can be part of a holistic strategy for safer cassava consumption.

Present various processing techniques used to reduce cyanide levels in cassava, such as soaking, fermentation, and cooking. (Google Slides: <https://docs.google.com/presentation/d/1goK-2xvTKNCKVtN8AaT9tvGfsB2_0-AgiV-8IPvbLo8/edit?usp=sharing>)

**Various Processing Techniques to Reduce Cyanide Levels in Cassava:**

1. Peeling:

* Method: Peeling involves removing the outer layer of the cassava, which is where cyanogenic glycosides are more concentrated.
* Effectiveness: While peeling helps reduce cyanide levels to some extent, it may not eliminate all cyanogenic glycosides, as they can penetrate into the inner tissues of the cassava.

2. Soaking:

* Method: Cassava is soaked in water for an extended period, typically ranging from several hours to overnight.
* Effectiveness: Soaking helps leach out water-soluble cyanogenic glycosides, reducing their concentration in the cassava. Discarding the soaking water before cooking further minimizes cyanide content.

3. Fermentation:

* Method: Cassava is fermented by allowing it to sit for an extended period, often with the aid of natural microorganisms or inoculants.
* Effectiveness: Fermentation breaks down cyanogenic glycosides into less toxic compounds, such as cyanohydrins. This process not only reduces cyanide content but also contributes to the development of desirable flavors and textures in fermented cassava products.

4. Boiling/Cooking:

* Method: Cassava is boiled or cooked before consumption.
* Effectiveness: Cooking disrupts the cellular structure of cassava, causing the release and volatilization of cyanide gas. This results in a significant reduction in cyanide levels, making the cassava safe to eat.

5. Sun Drying:

* Method: Slices or grated cassava is exposed to sunlight to facilitate drying.
* Effectiveness: Sun drying, coupled with subsequent cooking, has been shown to reduce cyanide levels. However, this method may be less effective compared to other processing techniques.

6. Combination of Methods:

* Method: Employing a combination of processing methods, such as peeling, soaking, and cooking, can enhance the overall reduction in cyanide levels.
* Effectiveness: Utilizing multiple methods synergistically addresses cyanide content at different stages, providing a comprehensive approach to ensuring the safety of cassava for consumption.

7. Breeding for Low Cyanide Varieties:

* Method: Agricultural research focuses on developing cassava varieties with naturally low levels of cyanogenic glycosides.
* Effectiveness: Plant breeding programs aim to create cassava varieties that are inherently safer for consumption, reducing the reliance on post-harvest processing to mitigate cyanide content.

\*\*\*Note: While these processing techniques can significantly reduce cyanide levels in cassava, it is crucial to emphasize the importance of culturally appropriate practices and education to ensure that communities are aware of and adopt safe processing methods. Additionally, adherence to these practices contributes to the overall nutritional and food security benefits of cassava consumption.

Hands-On Lab: Cassava Processing Demonstration (20 minutes):

* Conduct a demonstration of one or more cassava processing techniques. This could include peeling, soaking, or cooking cassava to reduce cyanide levels (as seen above). Emphasize the importance of proper processing in making cassava safe for consumption.

Experiment: Testing the pH of Water after Boiling Cassava

Cyanide Ion: when the cyanide ion reacts with water, it forms HCN:

CN**-** + 2H2O

→*→*

HCO2**-** + NH3

Cyanide + Water

→ *→*

Bicarbonate + Ammonia

\*\*\*Teacher Note: the chemical reaction occurs between cyanide (from cassava) and water to create bicarbonate (baking soda) and ammonia.\*\*\*

Objective: Students will

* investigate the effect of boiling cassava on the pH of water and determine if the process influences the acidity or alkalinity of the water.

Materials:

* Fresh cassava roots
* Knife and cutting board
* Distilled water
* Cooking pot
* pH test strips or pH meter
* Stirring rod
* Heat source (stove or hot plate)
* Timer
* Containers for boiling and testing water

Procedure:

1. Preparation:
* Wash and peel the cassava roots to remove any dirt or contaminants.
* Cut the cassava into uniform pieces to ensure consistency in the experiment.
1. Boiling Cassava:
* Place the cassava pieces in the cooking pot.
* Add enough distilled water to cover the cassava.
* Boil the cassava for a set period (e.g., 15-20 minutes).
* Stir occasionally to ensure even cooking.
1. Collecting Boiling Water:
* Once the cassava is boiled, carefully collect the water used for boiling in a separate container.
* Allow the water to cool to room temperature.
1. pH Testing:
* Dip a pH test strip into the water collected from boiling cassava, or use a pH meter according to the manufacturer's instructions.
* Record the pH reading.
1. Control Group:
* As a control, test the pH of distilled water that has not been in contact with cassava. This establishes a baseline pH for comparison.
1. Data Collection:
* Record the pH of both the cassava-boiled water and the control (distilled water).
1. Repeat Trials:
* Conduct multiple trials to ensure the reliability of the results.
* Vary the boiling time to observe potential differences in pH.
1. Data Analysis:
* Compare the pH of the cassava-boiled water to the control.
* Analyze the data to determine if boiling cassava has an impact on the pH of the water.
1. Safety Considerations:
* Take precautions while handling hot water and boiling cassava.
* Use proper kitchen safety measures, such as using heat-resistant gloves and keeping a safe distance from hot surfaces.
1. Conclusion:
* Evaluate the results to determine if boiling cassava influences the pH of water.
* Consider factors such as the presence of compounds released during boiling that may affect water pH.
* Discuss the implications of the findings and their relevance to cassava processing and food safety.

**LAB SHEET – Cassava and Cyanide**

Chemical Equation when the cyanide ion reacts with water:

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Materials:

Procedures:

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Data Table:

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| --- | --- | --- | --- |
| **Trial** | **Boiling Time (minutes)** | **pH of Cassava-Boiled Water** | **pH of Distilled Water (Control)** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |

Discussion Questions:

1. Did the pH of the cassava-boiled water differ from the control?
2. What factors might contribute to any observed changes in pH?
3. How could these findings be relevant to the safety of cassava consumption?
4. Are there additional variables that could be explored in future experiments?