Identification of Hydrogen Cyanide (HCN) Content in Purple Sweet Potato (*Ipomoeabatatas* L.) Soaking Water Soaked Using Coconut Water Via Liebig-Deniges Argentometric Titration Method

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Abstract

Purple sweet potato (*Ipomoea batatas* L.) contains cyanogenic glycosides that can potentially hydrolyze into hydrogen cyanide (HCN) upon tissue mechanical damage. This quantitative descriptive laboratory experimental study aimed to identify the presence and measure the concentration of HCN in sweet potato soaking water prepared with coconut water (*Cocos nucifera* L.) at a 1:2 ratio for 12 hours after an 8-day storage period. Qualitative identification was performed using saturated picric acid paper (8% Na_2CO_3) heated at 60°C. Quantitative determination was conducted in triplicates (n=3) via Liebig-Deniges Argentometric Titration utilizing 0.01N $AgNO_3$ standard solution, 5% KI indicator, and 6 M NH_4OH alkaline medium. The qualitative test yielded a positive result (+), indicated by the color transition of picrate paper from yellow to reddish-brown due to isopurpuric complex formation. In the quantitative assay, the titration endpoint was marked by a persistent pale-yellow turbidity, requiring an average titrant volume of 1.37 mL (1.30 mL, 1.40 mL, and 1.42 mL). Based on Liebig–Deniges volumetric calculations, the average concentration of dissolved HCN in the soaking water was 7.43 mg/L (ppm). This study demonstrates that the Liebig–Deniges Argentometric method is highly sensitive, specific, and effective for HCN quantification in natural liquid matrices.

Kata Kunci: *Coconut Water, Hydrogen Cyanide (HCN), Liebig–Deniges Argentometry, Sweet Potato (Ipomoea batatas L.).*

A. INTRODUCTION

Purple sweet potato (*Ipomoea batatas* L.) is one of the local food commodities in Indonesia rich in carbohydrates, bioactive compounds, and secondary metabolites (Iksanti et al., 2024). In addition to its high nutritional value, this plant from the Convolvulaceae family contains cyanogenic glycosides (such as linamarin and lotaustralin) which can be hydrolyzed by the endogenous enzyme linamarase into hydrogen cyanide (HCN) when its cell tissue undergoes mechanical damage or excessive storage (Ndubuisi & Chidiebere, 2018; Triana & Kamila, 2018). The formation of free HCN in tubers has the potential to cause high toxicity if not processed properly; however, on the other hand, this cyanide derivative compound has potential application in science and agriculture if extracted and managed appropriately (Lumbantobing et al., 2020).

Improper postharvest handling and tuber storage can trigger a physiological stress response in the form of accelerated cellular respiration and activation of

secondary metabolic pathways (Kusuma & Arifin, 2021). This stress condition stimulates the degradation of complex glycoside compounds in the cell vacuole, which then come into direct contact with the linamarase enzyme in the cell wall (Pratama et al., 2022). Consequently, the accumulation of hydrogen cyanide (HCN) in free or dissolved form undergoes a significant increase over storage time (Bolarinwa et al., 2022). Therefore, the mechanism of extraction and dissolution of HCN using natural media has become a focus of attention in food safety studies and pharmaceutical analysis (Setiawan et al., 2023).

Hydrogen cyanide (HCN) is highly reactive and readily binds to alkali metal cations, one of which is potassium ions (K^+). Coconut water (*Cocos nucifera* L.) is widely known as a natural liquid highly rich in dissolved electrolytes and potassium minerals (Az Zahra et al., 2024). The interaction between hydroxide ions and dissolved cations from coconut water with HCN gas resulting from tuber hydrolysis produces a dissolved cyanide complex solution (Emawati et al., 2025). The natural mineral content and relatively constant natural pH of coconut water act as a natural buffer capable of facilitating the desorption and stabilization of cyanide ions (CN^-) from the solid matrix of the tuber into the liquid phase (Suryani et al., 2021). To ensure the safety level of food materials as well as for analytical extraction purposes, the presence and concentration of HCN formed in the soaking water need to be accurately analyzed.

Quantification of Hydrogen Cyanide (HCN) levels in complex solutions requires a titrimetric method that is specific, sensitive, and undisturbed by dissolved organic matrices. The Liebig–Deniges Argentometric Titration method is a standard quantitative analysis method that is highly effective for cyanide content determination (Mardiyono, 2020). Differing from conventional argentometry, Deniges' modification utilizes the addition of ammonia solution (NH_4OH) and Potassium Iodide (KI) indicator (Lukum, 2022). Ag^+ ions from silver nitrate ($AgNO_3$) first react with cyanide ions (CN^-) to form a soluble complex $[Ag(CN)_2]^-$, and an excess of 1 drop of Ag^+ at the endpoint will react with I^- to form a very clear Silver Iodide (AgI) turbidity precipitate (Az Zahra et al., 2025; Septiani et al., 2022). The application of this method guarantees the validity and precision of HCN level measurement in sweet potato soaking water samples efficiently (Harmita, 2018; Kristanti & Rahmawati, 2020).

Therefore, this study was designed to conduct the Identification of Hydrogen Cyanide (HCN) Content in Purple Sweet Potato (*Ipomoea batatas* L.) Soaking Water Soaked Using Coconut Water via Liebig–Deniges Argentometric Titration Method to provide scientific clarity regarding the effectiveness of coconut water media in extracting and reducing cyanide levels in sweet potatoes (Hidayat et al., 2024).

B. METHODS

The equipment used includes burettes, analytical balances, Erlenmeyer flasks, beakers, drop pipettes, volumetric pipettes, rubber pipette bulbs, volumetric flasks, micropipettes, spatulas, glass funnels, aluminum foil, and filter paper. The materials

used include purple sweet potatoes from a market in the Ketanggungan area, fresh coconut water (*Cocos nucifera* L.), distilled water (aquadest), picric acid (Merck), tartaric acid (Merck), sodium hydroxide (Merck), sodium carbonate (Merck), potassium iodide (Merck), ammonium hydroxide (Merck), and silver nitrate ($AgNO_3$ Merck).

This study used a quantitative descriptive laboratory experimental approach to identify and measure Hydrogen Cyanide (HCN) levels in sweet potato (*Ipomoea batatas* L.) soaking water samples and coconut water. Purple sweet potatoes (*Ipomoea batatas* L.) obtained from a market in Ketanggungan region were sorted to ensure physical uniformity, peeled, and washed thoroughly using distilled water to remove remaining sap and external dirt. The sweet potatoes were then cut uniformly to a size of 2–3 cm. The sweet potato pieces were stored in a clean insulated container at room temperature (25°C ± 2°C) for 8 days to trigger physiological stress conditions in the tissue without causing biological decay or microbiological mold contamination.

After the storage period, the sweet potato samples were divided into three main treatment groups:

1. Main Sample Group: Purple sweet potato pieces were soaked in coconut water media (*Cocos nucifera* L.) at a sweet potato : coconut water ratio of 1:2 (w/v) for 12 hours.
2. Soaking Control Group: Purple sweet potato pieces were soaked in distilled water (aquadest) media at a ratio of 1:2 (w/v) for 12 hours as a comparison to evaluate the specific effectiveness of coconut water compared to pure solvent.
3. Media Blank Group: Pure coconut water without sweet potato soaking, processed in parallel as a corrector for matrix interactions of natural coconut water against the titrant reagent.

A total of 10 mL of soaking water sample was introduced into a 100 mL Erlenmeyer flask, then 2 mL of 5% tartaric acid solution was added, which served to release hydrogen cyanide (HCN) gas from the sample matrix. Furthermore, a strip of filter paper moistened with saturated picric acid solution (in 8% Na_2O_3) was suspended in the neck of the Erlenmeyer flask without touching the liquid surface, and the container was tightly stoppered. The Erlenmeyer flask was then heated on a water bath at 60 °C for 15 minutes to optimize HCN gas evaporation. The occurrence of a color change on the filter paper from yellow to reddish-brown indicated a positive result for the presence of cyanide ions (CN^-) in the sample (Muawanah et al., 2025).

A total of 25 mL of soaking water sample that had tested positive in the qualitative test was introduced into an Erlenmeyer flask, followed by the addition of 5 mL of 6 M NH4OH solution and 1 mL of 5% KI solution as an indicator. The mixture was then slowly titrated using 0.01 N AgNO3 standard solution while constantly swirled until homogeneous. The titration endpoint was marked by a visual change in the solution from clear to the emergence of persistent pale-yellow turbidity due to the formation of Silver Iodide (AgI) precipitate (Lukum, 2022).

$$HCN\ Content\ \left(\frac{mg}{L}\right) = \frac{[V_{titran}\ (ML) \times\ NAgNo_3 \times\ MW_{HCN}\ \times 100]}{[2\ \times\ V_{Sample}(mL)]}$$

Description:
V = Required volume of $AgNO_3$ (mL)
N = Normality of $AgNO_3$ (0.01 N)
MW_{HCN} = Molecular Weight of HCN (27.03 g/mol); the number 2 in the denominator is the valence/ stoichiometric factor of the Liebig–Deniges reaction (1 mol Ag+: 2 mol CN^-)
The number 1000 = Conversion factor from g/L to mg/L (ppm)
V_{sample} = Sample volume (25 mL)

C. RESULTS AND DISCUSSION

This study encompasses two main testing stages: qualitative identification of cyanide ions (CN^-) presence and quantitative content determination using the Liebig–Deniges Argentometric Titration method on sweet potato (*Ipomoea batatas* L.) soaking water samples soaked with coconut water.

Qualitative testing was conducted to confirm the presence of hydrogen cyanide (HCN) gas released from the soaking water sample matrix. Data from qualitative test results are presented in Table 1.

Table 1. Qualitative Test Results of Samples

Observation Parameter	Observation Result	Result	Description
Sample (Sweet Potato + Coconut Water)	Color change from yellow to reddish-brown	(+)	Confirmed containing cyanide (CN^-)
Control (Sweet Potato + Distilled Water)	Color change from yellow to reddish-brown	(+)	Contains cyanide ions (CN^-) due to water hydrolysis
Blank (Pure Coconut Water)	Remains yellow	(-)	Does not contain cyanide ions (CN^-)

Samples confirmed positive qualitatively were proceeded to the quantitative analysis stage using triplicate (n=3) argentometric titration method with 0.01 N $AgNO_3$ standard solution. Measurement data of titrant volume, calculation of HCN levels, and statistical precision evaluation are presented in Table 2.

Table 2. Quantitative Test Result Data of Volume Measurement (in Triplicate)

Sample Group	Replication	Sample Vol. (mL)	Gross $AgNO_3$ Titration Vol. (mL)	Blank Corrected Vol (V_{sample}-V_{blank}) (mL)	HCN Content (mg/ L)
Media Blank (Pure Coconut Water)	Average (^vblank)	25	0.05	-	0.00
Control (Sweet Potato + Distilled Water)	Average	25	0.93	0.88	4.76
Main Sample (Sweet Potato + Coconut Water)	Vol 1	25	1.35	1.30	7.03
	Vol 2	25	1.45	1.40	7.57
	Vol 3	25	1.47	1.42	7.68
Average	**-**	**25**	**1.42**	**1.37**	**7.43**

Qualitative test results indicated that purple sweet potato (*Ipomoea batatas* L.) soaking water samples soaked using coconut water yielded a positive (+) result, marked by a color change of picric acid indicator paper from yellow to reddish-brown. The formation of this cyanide compound is initiated by mechanical tissue damage in sweet potato during cutting and washing processes. Plant cell wounding triggers contact between cyanogenic glycosides, such as linamarin and lotaustralin, with the endogenous enzyme linamarase localized in the cell wall, thereby stimulating enzymatic hydrolysis reaction releasing free hydrogen cyanide (HCN) (Cressey & Reeve, 2021; Ndubuisi & Chidiebere, 2018). The use of coconut water (*Cocos nucifera* L.) as a soaking medium creates a specific ionic environmental condition. Coconut water is naturally rich in dissolved electrolytes and alkali cations, such as potassium and sodium, and is slightly alkaline, facilitating the dissolution and stability of cyanide ions (CN^-) resulting from tuber hydrolysis in the liquid medium (Az Zahra et al., 2024; Emma, 2024). The release of HCN gas from the sample matrix was proven upon the addition of 5% tartaric acid and heating at 60 °C, where HCN vapor reacted with picric acid in an alkaline environment (Na_2Co_3) forming a reddish-brown isopurpuric acid complex compound (Aulia et al., 2021; Muawanah et al., 2025).

The higher extraction efficiency of HCN in coconut water media (7.43 mg/L) compared to distilled water control media (4.76 mg/L) is influenced by the ionic strength of the solvent (Wahyudi et al., 2022). The presence of K^+ and Na^+ cations in coconut water forms soluble ionic pairs (KCN/NaCN), preventing dynamic evaporation of HCN gas back into the open air (Rahman et al., 2023). This salting-in phenomenon significantly increases the solubility of dispersed polar compounds in the soaking liquid (Sari & Handayani, 2021). Therefore, coconut water media is proven to act as a highly potential extracting agent for binding free cyanide compounds from tuber tissues (Wibowo et al., 2023).

After being confirmed positive qualitatively, quantitative determination of HCN content was performed using the Liebig–Deniges Argentometric Titration method. This Deniges modification method is highly specific for cyanide analyte in complex samples because it utilizes 6 M ammonia (NH_4OH) to form a stable amine complex and 5% Potassium Iodide (KI) solution as an endpoint indicator (Lukum, 2022; Mardiyono, 2020). The stoichiometric reaction during titration proceeds in two orderly chemical reaction stages. First, Ag+ ions from 0.01 N $AgNO_3$ titrant solution react with two molecules of CN^- ions from the soaking water sample to form a soluble, clear $[Ag(CN)2]^-$ complex. Second, after all CN^- ions are completely bound, an excess of one drop of Ag^+ ions will react with I^- ions from the KI indicator to form a sparingly soluble Silver Iodide (AgI) precipitate. The visual change from a clear solution to the appearance of persistent pale-yellow turbidity indicates that the titration endpoint has been precisely reached (Emawati et al., 2025; Septiani et al., 2022).

The use of KI indicator in Deniges modification was proven to eliminate false endpoint issues frequently occurring in conventional Liebig methods (Fitriana et al.,

2021). The presence of bright yellow AgI precipitate has a solubility product constant (Ksp = 8.3×10^{-17}) much smaller than AgCN precipitate, so turbidity will only form precisely when all free cyanide is completely reacted (Hutapea & Ramadhan, 2022). The alkaline condition from NH^4OH also prevents the precipitation of silver oxide (Ag_2O), which could interfere with endpoint reading (Yuliani et al., 2020). Consequently, the Liebig–Deniges method produces high accuracy and minimal random error limits (Nugroho et al., 2024).

Based on testing conducted in triplicates (n=3), corrected $AgNO_3$ 0.01N titrant volumes obtained were 1.30 mL, 1.40 mL, and 1.42 mL, respectively, giving a net average titrant volume of 1.37 mL. Based on the Liebig–Deniges volumetric equation with HCN Molecular Weight (MW) of 27.03 g/mol, reaction stoichiometric factor of 2, and sample volume of 25 mL, calculation of average dissolved HCN concentration in sweet potato soaking water and coconut water sample yielded 7.43 mg/L (ppm).

Viewed from safety and food security aspects, the maximum threshold of hydrogen cyanide (HCN) content permitted in tuber-based food materials according to Food and Agriculture Organization (FAO/WHO) and National Agency of Drug and Food Control (BPOM) is 10 mg/kg (10 ppm). The dissolved HCN content of 7.43 mg/L (7.43 ppm) extracted into soaking water is below acute danger threshold. This indicates that soaking process using coconut water for 12 hours is proven capable of extracting and transferring a major portion of cyanide toxins from solid tuber matrix into liquid phase, thus effectively lowering potential toxicity of sweet potato if subsequently processed further for consumption. Measured cyanide concentration proves that Liebig–Deniges Argentometric method is highly sensitive and accurate for quantitative analysis of cyanide in natural ingredient soaking water media without interference from dissolved organic matrix (Az Zahra et al., 2025; Harmita, 2018).

D. CONCLUSION

Based on results of conducted research, it can be concluded that purple sweet potato (*Ipomoea batatas* L.) soaking water sample soaked using coconut water tested positive (+) containing cyanide in qualitative analysis. Based on quantitative determination using Liebig–Deniges Argentometric Titration method with reaction stoichiometric factor correction (1 mol Ag^+: 2 mol CN^-), average dissolved Hydrogen Cyanide (HCN) content obtained was 7.43 mg/L (ppm) from an average 0.01 N $AgNO_3$ titrant volume of 1.37 mL. This level is below FAO/WHO standard food toxicity maximum limit (10 ppm). This proves that Liebig–Deniges Argentometric method is sensitive and effective when stoichiometric calculation and blank correction are applied precisely.

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