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# PRELIMINARY PHYSICOCHEMICAL CONTENTS AND ANTIOXIDANT PROPERTIES OF COCONUT WATER IN TRINIDAD AND TOBAGO

***Muhammad Sani Ismaila*[1], *Makella Joseph*[2], *Crista Nexar*[3], *Celine Ramdhan*[4], *Faith Appoo*[5], *Venkatesan Sundaram*[6], *Kavita Ranjeeta Lall*[7], *Kegan Romelle Jones*[8]**

[1] ORCID: 0000-0003-0266-8074
[2] ORCID:0009-0009-0502-4101
[3] ORCID:0009-0002-8726-2865
[4] ORCID:0009-0008-2096-1614
[5] ORCID 0009-0009-8638-7819
[6] ORCID:0000-0002-7665-2836
[7] ORCID: 0000-0002-6024-2795
[8] ORCID: 0000-0002-1260-7606
[1–8] Department of Basic Veterinary Sciences (DBVS)
School of Veterinary Medicine (SVM), Faculty of Medical Sciences
University of the West Indies, St. Augustine Campus, Trinidad and Tobago

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Abstract

The chemical, mineral, and antioxidant properties of two species of young coconut water (yellow and green) from Trinidad and Tobago were quantitatively analyzed and compared. Parameters such as Total Phenolic Content (TPC), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, Total Soluble Solids (TSS), Titratable Acidity (TA), pH, turbidity, and mineral composition were evaluated. The results revealed distinct differences in mineral concentrations, chemical properties, and antioxidant activity between the two coconut species. The green coconut water (Atlantic Tall) exhibited significantly higher antioxidant activity in both DPPH and TPC assays compared to the yellow coconut water (Malayan Dwarf) ($p < 0.05$). Although the crude extract yield was marginally higher in yellow coconut water, this difference was not statistically significant ($p > 0.05$). No significant differences were observed between the two species in terms of TSS and pH (p>0.05). However, the titratable acidity was higher in the green coconut water ($p < 0.05$), while the yellow coconut water exhibited greater turbidity ($p < 0.05$). The yellow coconut water also had higher concentrations of Na, K, Ca, and Mg ($p < 0.05$), though there was no significant difference in iron (Fe) content ($p > 0.05$). Overall, the findings suggest that coconut water from Trinidad and Tobago is rich in essential minerals and possesses notable antioxidant properties, with variability between the two species in certain chemical and physical characteristics.

Address: Muhammad Sani Ismaila, University of the West Indies, St. Augustine Campus, Trinidad and Tobago, e-mail: sanimuhammad.ismaila@uwi.edu

## Introduction

Coconut (Cocos nucifera), a member of the Arecaceae family, is a widely recognized fruit known for its nutritional and therapeutic potential (Debmandal and Mandal 2011). Coconut trees thrive along tropical, sandy shorelines, where they can withstand salt spray and brackish soils, growing well in a wide range of soil types with a pH between 5 and 8 (Broschat and Crne 2000). The fruit itself is composed of water, sugars, vitamins, and essential minerals such as potassium, sodium, magnesium, iron, and calcium, though its composition can vary among species (Prades et al. 2012).

In Malaysia, studies have shown that coconut water can effectively rehydrate the body after exercise, offering a viable alternative to water or carbohydrate-electrolyte beverages (Saat et al. 2002). Additionally, coconut water has been reported to possess significant antioxidant properties (Mantena et al. 2003). Oxidative stress, caused by free radicals produced during oxygen metabolism, can lead to cellular damage, contributing to conditions such as liver and heart diseases, as well as certain cancers. Antioxidants neutralize these free radicals, potentially preventing or reducing oxidative damage (Ware 2018). Given its high antioxidant activity, coconut water may serve as a beneficial supplement in combating oxidative stress and associated diseases (Ajeigbe et al. 2023, Ojiha et al. 2022, Rethinam and Krishnakumar 2022). However, further research is necessary to validate these claims.

In preclinical studies, green coconut water has been shown to alleviate oxidative stress in hypoglycemic rats (Preetha et al. 2012). In the Caribbean, Trinidad and Tobago's coconut industry has a long history, with the first coconut estate established in Mayaro in the 1900s, followed by the Cedros and Constance estates. The Woodland estate in Tobago dates to the 1800s. Despite the challenges posed by Red Ring disease, which has impacted coconut tree populations, the industry remains active, producing a variety of coconut-based products, including milk, copra, water, dry nuts, and oil. In Trinidad and Tobago, coconuts are multifunctional, serving culinary, religious, recreational, economic, and medicinal purposes (Pemberton et al.1992).

Bordeix et al. (2020) identified three primary species of coconut palms: tall, dwarf, and hybrid varieties. In Trinidad and Tobago, five known varieties include the Malayan dwarf yellow, Malayan dwarf green, Atlantic tall (Jamaican tall), Malayan dwarf red, and non-descript hybrids. While studies from around the world have explored the bioactive compounds, minerals, and antioxidant properties of coconut water, to the best of our knowledge, such research has not been conducted in Trinidad and Tobago or the broader Caribbean region. Moreover, while studies have compared the antioxidant activity of young and mature coconuts, there has been limited focus on comparing coconut water from different species of young coconuts. For instance, FONSECA et al. (2009) compared the antioxidant activity of green and yellow coconuts in Brazil, but details regarding the specific varieties and ages of the coconuts were not provided.

This study aims to fill this gap by providing preliminary data on the mineral composition and antioxidant content of coconut water in Trinidad and Tobago. It will specifically compare the young coconut water of two distinct species: the Atlantic tall coconut (green coconut) and the Malayan yellow dwarf coconut (yellow coconut).

## Materials and Methods

### Chemical reagents

The following chemical reagents were purchased from Sigma-Aldrich, Germany: methanol, 2,2-diphenyl-1-picrylhydrazyl (DPPH), Folin-Ciocalteu phenol reagent, gallic acid, sodium hydroxide, malic acid, and distilled water.

### Coconut water collection

Ethical approval for the study was obtained from the University of the West Indies, Trinidad and Tobago, with the approval number Ref: CREC-SA.2467/12/2023. Three young green Atlantic Tall coconuts (GCW) were harvested from a coconut tree in Chaguanas, Trinidad, and three young yellow Malayan Dwarf coconuts (YCW) were collected from a tree in Couva, Trinidad. The coconuts were hand-picked and stored at room temperature for one day before being submitted to the laboratory. On the day of sample collection, all six coconuts were opened. The volume of coconut water from each coconut was measured and recorded. The water from the three green coconuts was pooled and labeled as "green" and the water from the three yellow coconuts was pooled and labeled as "yellow." The samples were stored at 4°C in a refrigerator until further analysis.

### Antioxidant activity

**Extraction of coconut water**. The extraction of coconut water was conducted according to the method described by MAHAYOTHEE et al. (2016).

Briefly, 20 g of coconut water was mixed with methanol at a 1: 5 (v/v) ratio and shaken for 3 hours at room temperature using an orbital shaker set at 90 rpm. The mixture was then filtered using Whatman No. 4 filter paper, and the resulting extract was evaporated under reduced pressure at 50°C using a rotary evaporator. The concentrated extract was adjusted to a final volume of 10 mL with methanol in a volumetric flask for further analysis. All experiments were performed in triplicate.

**Percentage yield of the coconut water**. Percentage yield [%] = Weight of the extracted coconut water sample/Total weight of the sample · 100.

**Antioxidant activity (DPPH)**. DPPH radical scavenging activity was measured using a modified method from Mahayothee et al. (2016). Briefly, 0.1 mL of the diluted coconut water extract was mixed with 3.9 mL of $6 \cdot 10^{-5}$ M DPPH solution in methanol. The mixture was incubated at room temperature in the dark for 2 hours. Absorbance was measured at 515 nm using a UV-Vis spectrophotometer. The DPPH radical scavenging activity [%] was calculated using the formula:

$$\frac{A_0 - A_S}{A_0} \cdot 100,$$

where $A_0$ is the absorbance of the DPPH solution without the sample, and $A_S$ is the absorbance of the DPPH solution with the sample.

**Total Phenolic Content (TPC) Determination**. The total phenolic content (TPC) of the coconut water was measured using the Folin-Ciocalteu method with modifications (Tan et al. 2014). A stock solution of gallic acid (500 mg/L) was prepared in deionized water, and working standard solutions were prepared by serial dilution to final concentrations of 20, 40, 60, 80, and 100 mg/L. For the analysis, 1 mL of coconut water was mixed with 70 mL of distilled water and 5 mL of Folin-Ciocalteu phenol reagent (10-fold dilution). The mixture was incubated for 5 minutes at room temperature, followed by the addition of 15 mL of 7.5% (w/v) sodium carbonate. The volume was then brought to 100 mL with distilled water, and the mixture was incubated for 2 hours at room temperature. Absorbance was measured at 765 nm using a UV-1650 PC UV-Vis spectrophotometer. TPC was expressed as gallic acid equivalents (GAE) in mg/L.

## Chemical and Mineral Analysis

**Total Soluble Solids (TSS) measurement**. The TSS of coconut water was determined using a digital refractometer (at 25°C), and results were expressed in Brix.

**Titratable Acidity (TA)**. Titratable acidity was measured using the Titratable Acidity in Wine or Juice method. Five milliliters of degassed coconut water was transferred to a 250 mL Erlenmeyer flask, and 100 mL of neutralized deionized water was added. The solution was titrated with 0.1 N NaOH until a faint pink color persisted for 30 seconds. TA was calculated using the following equation:

$$NN \cdot MM \cdot VV \cdot 100/Vc,$$

where:
NN – normality of NaOH,
VV – the volume of NaOH used,
*V*c – the volume of coconut water,
MM – the malic acid factor (67.05).

**pH measurement**. The pH of the coconut water was determined using a pH meter equipped with a pH electrode.

**Turbidity measurement**. Turbidity was measured using a UV-Vis spectrophotometer at 610 nm. Absorbance was measured relative to distilled water, and the transmittance ($T$) and turbidity were calculated using the following equations:

$$T = 100 \cdot (10^{Abs}),$$

where: Abs was the adsorption at a wavelength of 610 nm.

$$\text{Turbidity} = 100 - T,$$

where: $T$ was the transmittance at a wavelength of 610 nm.

**Mineral content analysis**. The concentrations of sodium (Na), magnesium (Mg), calcium (Ca), potassium (K), and iron (Fe) in coconut water were determined using a flame atomic absorption spectrophotometer, following the method of Tan et al. (2014). All assays were performed in triplicate.

**Statistical analysis.** Data were analyzed using SPSS statistical software. Descriptive statistics, including means and standard deviations, were calculated. To compare the means of the different coconut varieties, a Student's t-test was used. A $p$-value of $< 0.05$ was considered statistically significant. All analyses were conducted in triplicate.

# Results and Discussion

## Results: yield, DPPH, and TPC of the two coconut species

Our findings indicate that there was no significant difference ($p > 0.05$) in yield (YCW : 2.53% and GCW : 2.24%) between the two species of coconut, as shown in Figure 1. However, the DPPH radical scavenging activity and total phenolic content (TPC) were significantly higher ($p < 0.05$) in the green coconut water (GCW) compared to the yellow coconut water (YCW), as illustrated in Figure 1.

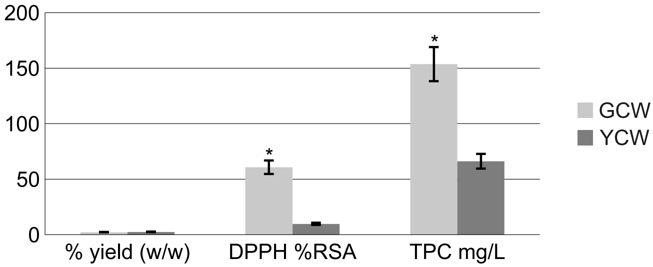


Fig. 1. Total yield of coconut water extract, DPPH radical scavenging activity, and total phenolic content of the two coconut varieties

Each value in the diagram represents a mean ± SD ($n$ = 3), *Indicates a significant difference between the two different samples ($p < 0.05$). Explanations: YCW – Yellow coconut water; GCW – green coconut water; DPPH (2,2-diphenyl-1-picrylhydrazyl); TPC – total phenolic content.

Table 1

The volume of coconut water obtained from the coconut water varieties, quantity after extraction and the % yield

| Specification | Please remove the asterisk from YCW [ml] | GCW [ml] |
|---|---|---|
| 1 | 280 | 360 |
| 2 | 330 | 350 |
| 3 | 330 | 350 |
| Total | 940 | 1060 |
| Quantity obtained after extraction | 23.78 | 23.74 |
| % yield | 2.53% | 2.24% |

YCW – yellow coconut water; GCW – green coconut water

## The mineral content of yellow and green coconut water

The Malayan Yellow Dwarf coconut water contained higher levels of all minerals compared to the Atlantic Tall variety ($p < 0.05$). However, no significant difference in iron content was found between the two varieties ($p > 0.05$) – Table 2.

Table 2

The mineral content of yellow and green coconut water

| Parameter | YCW [mg/l] | CGW [mg/l] |
|---|---|---|
| Sodium (Na) | 134.28 ±2.73$^a$ | 78.20 ±4.10$^b$ |
| Potassium (K) | 2143.21 ±11.43$^a$ | 1546.91 ±45.76$^b$ |
| Calcium (Ca) | 288.75 ±1.45$^a$ | 243.16 ±1.38$^b$ |
| Magnesium (Mg) | 82.23 ±0.73$^a$ | 41.72 ±0.60$^b$ |
| Iron (Fe) | 0.108 | 0.161 |

$^{a, b}$superscripts denote significant differences ($p < 0.05$) within rows

## Physico-chemical properties of yellow and green coconut water

No significant difference was observed ($P > 0.05$) in the total soluble solids (TSS) between the two coconut varieties (Table 3). However, a significant difference was found ($P < 0.05$) between the two varieties in terms of acidity and turbidity, as shown in Table 3.

Table 3

Physico-chemical properties of yellow and green coconut water

| Parameter | YCW [mg/l] | GCW [mg/l] |
|---|---|---|
| Total soluble solids [% Brix] | 4.67 ±0.50 | 4.67 ±0.50 |
| Titratable acidity [%w/v Malic acid] | 0.091 ±3.45$^a$ | 0.076 ±2.99$^b$ |
| pH | 4.76 ±0.09 | 4.66 ±0.02 |
| Turbidity (NTU) | 116.67 ±2.08$^a$ | 138.33 ±0.58$^b$ |

$^{a, b}$ superscripts denote significant differences ($p < 0.05$) within rows

# Discussion

Quantifying the antioxidant and mineral content of substances intended for medicinal applications is crucial for assessing their potential health benefits. To the best of our knowledge, this study is the first conducted in Trinidad to identify and quantify indigenous coconut water's antioxidant and mineral content. The findings of this study, including total phenolic content (TPC), DPPH radical scavenging activity, and the yield of crude coconut water extract, are presented in Figure 1.

Our results indicate that the Malayan Yellow Dwarf coconut water produced a slightly higher yield (2.53%) compared to the Atlantic Tall coconut water (2.24%), though this difference was not statistically significant ($p > 0.05$).

While no previous studies have directly compared the antioxidant activity of Atlantic Tall and Malayan Yellow Dwarf coconut waters, a 2012 study in Brazil (Santos et al. 2013) demonstrated that Malayan Green

Dwarf coconut water protected against oxidative stress induced by hydrogen peroxide. This suggests that coconut water from Malayan Green Dwarf coconuts may be beneficial in preventing oxidative damage in humans and animals. However, further research is necessary to confirm these potential benefits.

In our study, the Atlantic Tall coconut water exhibited higher antioxidant activity than the Malayan Yellow Dwarf variety. The DPPH analysis showed a 60.7% radical scavenging activity for the Atlantic Tall variety, compared to only 9.8% for the Malayan Yellow Dwarf. Similarly, the TPC was significantly higher in the Atlantic Tall coconut water, with a value of 153.7 mg/L, compared to 66.2 mg/L for the Malayan Yellow Dwarf. Antioxidants play a critical role in scavenging free radicals in the body, thereby reducing oxidative stress and preventing cellular damage (WARE 2018). The DPPH assay is widely used to evaluate antioxidant capacity because it measures the ability of a substance to neutralize free radicals (BALIYAN et al. 2022). Phenolic compounds are widely known for their antioxidant properties. Previous research with coconut water in fruit flies shows that the reducing power and scavenging ability of coconut water (CW) could be attributed to the total flavonoid and total phenol content and high concentration of the phenolics which leads to a significant reduction in the generation of free radicals and MDA level in the brain of $Alcl_3$ induced amnesic *D. melanogaster* fed with coconut water supplemented diet (OLUWAROTIMI et al. 2021).

Our study's findings are consistent with those of MAHAYOTHEE et al. (2016) and SANTOS et al. (2013). MAHAYOTHEE et al. (2016) reported TPC values ranging from 6.2 to 10.01 mg/g in coconut water from Thailand, while SANTOS et al. (2013) found TPC values for Malayan Green Dwarf coconut water to be 99.4 µg/mL, and for Malayan Yellow Dwarf, 23.8 µg/mL. In comparison, the antioxidant content of Trinidadian coconut water appears higher. At a concentration of 0.1 mL/mL, our DPPH radical scavenging activity was also significantly greater, indicating that coconut water from Trinidad has a higher antioxidant capacity than that from Thailand and Brazil.

Coconut water has long been used as an effective oral rehydration drink, thanks to its electrolyte composition, which includes essential minerals such as calcium, potassium, iron, magnesium, and sodium. These minerals are vital for maintaining the body's acid-base balance. In a study conducted in Pakistan, KHAN et al. (2003) reported that coconut water can aid in rehydration, especially during mild diarrhea, due to its high glucose content and easy absorption properties. Our study found that coconut water from Trinidad and Tobago contained particularly high concentrations of calcium, potassium, sodium, and magnesium compared to those reported in other studies. Specifically, the Malayan Yellow Dwarf coconut water had higher levels of these minerals than the Atlantic Tall variety ($p < 0.05$). However, no significant difference in iron content was observed between the two varieties ($p > 0.05$). Similar studies conducted in Sri Lanka, Brazil, and Malaysia have also documented high mineral concentrations in coconut water, though the values reported in those studies do not align with our findings.

In addition to antioxidant and mineral content, we also evaluated the chemical properties of the coconut water, including total soluble solids (TSS), titratable acidity (TA), pH, and turbidity. Our results indicated no significant difference in TSS and pH between the Malayan Yellow Dwarf and Atlantic Tall coconut waters ($p > 0.05$). However, significant differences were observed in TA and turbidity ($p < 0.05$), with the Malayan Yellow Dwarf variety having higher TA values and the Atlantic Tall coconut water being more turbid. Titratable acidity is often a more reliable indicator of a substance's perceived acidity and flavor profile than pH alone. Our TA values were 0.091% and 0.076% for the Malayan Yellow Dwarf and Atlantic Tall varieties, respectively, consistent with values reported by Mahayothee et al. (2016), who found TA values of 0.09% and 0.07%. Our pH values, which were 4.76 and 4.66 for the Malayan Yellow Dwarf and Atlantic Tall coconut waters, respectively, align with those observed in other studies, which reported pH values ranging from 4.84 to 5.84 (Mahayothee et al. 2016, Tan et al. 2014).The studies by Mahayothee et al. (2016) and Tan et al. (2014) explored the composition of coconut water at different stages of maturity, with consistent findings regarding pH and total phenolic content (TPC). Specifically, Mahayothee et al. (2016) highlighted those young coconuts, harvested at 190 days after planting, exhibited moderate acidity, balanced sweetness, and high TPC compared to mature coconuts. This aligns with the findings in this study, which also observed similar characteristics in young coconut water.

Furthermore, Tan et al. (2014) documented that young coconuts have a lower pH and higher TPC values when compared to matured coconut water, reinforcing the trend that the maturity stage of coconuts significantly affects their chemical composition. These results suggest that the age of the coconut at harvest plays a critical role in determining the acidity, sweetness, and phenolic content of coconut water, with younger coconuts being particularly rich in beneficial compounds.

Regarding TSS, our study found values of 4.67 and 4.70 for the Malayan Yellow Dwarf and Atlantic Tall varieties, respectively, which are lower than the TSS values reported in Thailand and Brazil, where young coconuts were found to have TSS values between 5.60 and 7.7. This suggests that coconut water from Trinidad and Tobago may have a lower sugar content compared to coconut water from other regions. The concept of Total Soluble Solids (TSS) in coconut water is important because it directly impacts the concentration of sugars, minerals, and other bioactive compounds present. TSS is typically a measure of the total dissolved solids in a liquid, including sugars, organic acids, proteins, amino acids, and salts. In the case of coconut water, TSS content can be affected by factors like the age of the coconut, its variety, and environmental conditions during cultivation. Low TSS in coconut water means that the sugar content is relatively low compared to other reported. This characteristic makes the Trinidad coconut water an excellent option for rehydration, especially in cases of mild dehydration, as it delivers a significant quantity of electrolytes (e.g., potassium, sodium, magnesium, and calcium) without overloading the body with excessive sugars. Coconut water with low TSS may have a lower glycemic index which helps in controlling blood sugar spikes in individuals with Type 2 diabetes, less disruptive effect on gut microbiota. Coconut water with lower total soluble solids (TSS) has significant medicinal implications, particularly for rehydration, metabolic health, and gastrointestinal function (Prades et al. 2012, Rethinam and Krishnakumar 2022).

## Conclusion

The findings of this study clearly demonstrate that coconut water from Trinidad and Tobago possesses notable antioxidant, chemical, and mineral properties. Both the Malayan Yellow Dwarf and Atlantic Tall coconut water (green) exhibit antioxidant activity, with the Atlantic Tall variety showing the most significant antioxidant potential, suggesting it could serve as an effective supplement to combat oxidative stress. On the other hand, the Malayan Yellow Dwarf variety contains higher mineral content compared to the Atlantic Tall, making it a more suitable candidate for fluid therapy and a natural alternative to commercially available rehydration solutions. Both coconut water varieties are slightly acidic with a sweet taste, though the Atlantic Tall is more turbid in appearance. As indicated by the low Total Soluble Solids (TSS) levels, the low sugar content makes coconut water from Trinidad and Tobago a safer option for individuals concerned about blood sugar levels, while still providing essential electrolytes and antioxidants. Future studies could further investigate the role of TSS in enhancing the health benefits of coconut water, potentially leading to customized formulations for specific health needs.

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