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ORIGINAL ARTICLE

Assessment of Quality Parameters of Coconut Water from Six Distinct Coconut Varieties in Sri Lanka

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Abstract

Coconut water is a naturally occurring isotonic drink that has gained popularity owing to its refreshing and health-promoting effects. This study was conducted as an in-depth study of the water quality of six coconut varieties: Green Dwarf, Red Dwarf, Ran Thambili, Gon Thambili, CRIC 60, and CRIC 65. The physicochemical, nutritional and functional properties of coconut water from the nuts were determined at 11 months of maturity. One-way ANOVA was used to statistically analyse the obtained data. Significant differences ($p < 0.05$) were observed among varieties for most physicochemical parameters, except for colour and titratable acidity. The pH ranged from 5.15 ± 0.04 to 6.95 ± 0.03, while the Brix value ranged from 3.20 ± 0.44 to 4.53 ± 0.11 °Bx. All varieties were identified as rich sources of potassium (344.26 ± 43.5 to 854.51 ± 21.7 mg/L). Nutritional analysis revealed significant variations in ash (0.65–1.30%), protein (0.20–0.78%), and total sugar contents (2.01–3.54 g/100 mL), whereas fat content remained minimal across all varieties (0.03–0.18%). Gon Thambili exhibited higher total phenolic (7.85 ± 2.58 mg GAE/100 mL) and flavonoid contents (0.26 ± 0.06 mg QE/mL), while CRIC 65 demonstrated the highest antioxidant capacity (10.51 ± 1.10 mg Trolox/g). Altogether, tested coconut varieties exhibited significant differences in physicochemical, nutritional and functional attributes, which support their nutraceutical value as an excellent natural source of potassium and sodium.

***Keywords**: Cocos nucifera L, cultivar variation, functional properties, phytochemical properties*

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1. Introduction

Coconut (*Cocos nucifera* L) is a versatile and economically significant tropical plant that belongs to the Arecaceae family. Admired as the "Tree of Life" in many cultures, coconuts have played an integral role in the livelihoods, cultures, and economies of numerous countries across the globe. This iconic palm tree is native to coastal regions of tropical countries and is famed for its multifaceted uses, ranging from culinary and medicinal purposes to industrial and agricultural applications. From the root to the leaf, each component of the palm has been valued for specific purposes. The coconut fruit is the most important component, which has a high market value. There are two edible components in the nut's endosperm (inner portion): a white kernel and a transparent fluid component. The kernel of mature coconut has a high amount of fats (50-60 %) and it's used to make coconut milk, cream and used for baking and cooking as well (Appaiah et al. 2015). Moreover, coir, the fibrous material extracted from the husk of the nut, finds application in various products, including ropes, mats, and brushes, showcasing the plant's remarkable versatility.

Coconut water, the clear liquid found inside coconuts, starts to form about two months after the inflorescence naturally opens. It has gained significant attention in recent years as a natural beverage with numerous health benefits and hydrating properties. This liquid component of coconut, often regarded as a sweet refreshing drink, is not only delicious but also packed with essential nutrients. With a composition rich in electrolytes, vitamins, and minerals, coconut water has been traditionally consumed in tropical regions for centuries.

Studies have shown that coconut water contains high levels of potassium, sodium, calcium, and magnesium, crucial electrolytes that aid in maintaining proper fluid balance and muscle function (Campbell-Falck et al. 2000). Coconut water makes up 25% of the fruit's weight and it's mostly composed of 95.5% of water. It is naturally isotonic due to its mineral content and moderate total sugar level. Depending on its age during harvest, coconut water can be categorized as: tender coconut water and mature coconut water (Silva & Bamunuarachchi 2009). The nutritional value of coconut water hasn't altered much as the coconut matures, but the water content gradually lowers, and the flavour quality deteriorates, when crude fat level rises (Zhang et al. 2018). The natural quality of coconut water can be maintained if it remains in the nuts' interior chamber, but when the nut is opened its' biochemical makeup and external appearance alter. Studies have explored various thermal and non-thermal treatments, often combined with additives to preserve the quality of coconut water (Prades et al. 2012).

In certain regions, coconut water is used as a natural hydration solution, as part of a daily diet, when nutritional deficiencies are severe (Vigliar et al. 2006). It's also used to cure hiccups, indigestion, gastritis, dysuria, burning pain in the eyes, and burning pain while urinating (Tuyekar et al. 2021). Research suggests that coconut water can be utilized to replace electrolytes in various conditions

(Kuberski et al. 1979). The chemical makeup of coconut water has been compared to teas, soft drinks, carbonated soft drinks (Chavalittamrong et al. 1982) and isotonic drinks and oral rehydration solutions.

Coconut water is gaining popularity for its health benefits and taste, but there exists a significant gap in scientific research concerning its nutritional composition and physical and chemical attributes across different varieties. Also, the studies comparing the properties of coconut water in different traditional and improved varieties at a specific stage of maturation of coconut palms are lacking. Moreover, In Sri Lanka, coconuts are mainly utilized for products such as coconut kernel, desiccated coconut, and copra. However, the coconut water component is often underutilized or discarded during processing, particularly in mature nuts. Considering the nutritional and functional potential of coconut water, evaluating its physicochemical and nutritional characteristics could support its utilization as a value-added product and reduce wastage of this valuable natural resource. This study aims on conducting a comprehensive analysis by comparing the nutritional content, physical and chemical properties of coconut water from six different Sri Lankan coconut varieties, both traditional and improved. This facilitates consumers to make informed choices, manufacturers optimize their production, and researchers understand the health potential of coconut water.

2. Materials and Methods

In order to compare the physical, chemical, nutritional and functional properties of coconut water, six different coconut varieties namely, green dwarf, red dwarf, *Ran thambili*, *Gon thambili,* CRIC 60 and CRIC 65 were collected from the Coconut Research Institute at Lunuwila, Sri Lanka.

2.1. Sample Preparation

2.1.1. Harvesting of coconuts

Coconuts of 11 months maturity stage were obtained. In each variety, three nuts from each plot (nut per tree) were taken as one replicate, and thus nine nuts from three separate plots were harvested for three replicates.

2.1.2. Obtaining coconut water

Coconuts were de-husked, and the water was hygienically collected by piercing the middle eye of each nut. Water was collected into sterilized glass bottles by filtering through a muslin cloth. Water from three nuts of three random trees harvested in one plot was made into a composite mixture for analysis. In total, three composite mixtures were made under one variety that represents three different replicates. The bottles were stored in a refrigerator at 4 °C until further analysis.

2.2. Determination of Physical Properties

Nut weight, nut circumference, water volume of nuts, specific gravity and the colour of coconut water were measured. The CIE L*, a*, and b* parameters were determined using colorimeter (BCM-200, China) under colour determination. Also, the whiteness index of coconut water samples was calculated using (Eq. 1) from the mean values of L*, a* and b* using a method suggested by Milovanovic et al. (2020).

Whiteness index = 100 - √ ((100 – L)2 + a2 + b2)--Eq. 1

2.3. Determination of Chemical Properties

2.3.1. Total Soluble Solids (TSS)

The total soluble solid content of each coconut variety was determined according to Ali et al. (2018), using a digital refractometer (PAL-17S, China).

2.3.2. Titratable Acidity (TA)

Titratable acidity was determined by titration of one millilitre of sample with 0.l N NaOH until pink colour appeared (Anyasi et al. 2015). Phenolphthalein was used as the indicator. The percentage titratable acidity was expressed as citric acid percentage (Eq. 2).

TA% = (N ×V × Equivalent weight)/ (M ×1000)---Eq. 2

N - Normality of the titrant (NaOH)

V - Volume of titrant

Equivalent weight of the predominant acid

M - Mass of sample

2.4. Determination of Nutritional Properties of the Selected Coconut Varieties

The ash content (AOAC 942.05), crude fat (AOAC 2003.05), and protein content (AOAC 2001.11) of the coconut water of six varieties were determined according to the standard methods of AOAC (2019).

2.4.1. Total sugar content

Total sugar content of the samples was determined by using the phenol-sulfuric method as described by Fernando et al. (2014) with some modifications. Hundred milligrams of the sample and five millilitres of 2.5 N HCl was heated in the water bath for three hours and allowed to cool to room temperature. Na2CO3 was added to neutralize until effervescence ceased and thereafter the mixture was diluted to 100 mL using distilled water. The prepared solution was centrifuged, and the supernatant (0.2 mL) was taken and diluted to 1 mL using distilled water. Thereafter, 1 mL of 5 %

phenol and 5 mL of 96 % sulfuric acid were added and mixed well. The resultant solution was heated in a water bath at 30 °C for 20 min. One ppm of D-glucose was used to prepare the standard series of 0.2, 0.4, 0.6, 0.8, and 1 ppm. Blank was done by using distilled water. The absorbance was measured at 490 nm using a Spectrophotometer (HACH DR 3900, Germany) for both the sample solutions and D-glucose standard solutions. The total sugar content was calculated using the standard curve and expressed as g/100 g.

2.4.2. Mineral composition

Potassium and Sodium contents were analysed using a flame photometer (Model 360 Sherwood's Scientific's Single Channel Analogue, UK). Wet ashing method was used to prepare the samples (AOAC 2019). Standard solution of Potassium (400 ppm) and Sodium (1000 ppm) were prepared by dissolving 0.76 g KCl (analytical grade, ≥99% purity) in one litre and dissolving 2.54 g of NaCl (analytical grade, ≥99% purity) in one litre of distilled water, respectively. Mineral concentration was calculated using the standard curves and expressed as mg per kg (ppm).

2.5. Determination of the Functional Properties of the Selected Coconut Varieties

2.5.1. Total flavonoid content

Total flavonoid content of the samples was determined by the aluminium chloride colorimetric method according to the methods described by Chang et al. (2002) and Zhishen et al. (1999) with some modifications. Five milligrams of quercetin was dissolved in 5 mL of methanol. A standard solution series was prepared by obtaining 5000 µg/mL of quercetin solution and performing a two-fold serial dilution. A standard series of 500, 250, 125, 62.5, 31.25, 15.63, 7.81, 3.91, 1.95, and 0.97 µg/mL was prepared. One millilitre of the sample or quercetin standard solution or blank solution was added to 10 mL of volumetric flask. Four millilitres of distilled water was added to the solution followed by adding 0.3 mL of five percent sodium nitrite at the beginning. Five minutes later, 0.3 mL of 10 % aluminium chloride was added to the mixture. At the sixth minute, 2 mL of 1M NaOH was added to the mixture and was volumed up with 10 mL of distilled water. The content was mixed well. After 15 minutes the absorbance was recorded at 415 nm. Readings were obtained in duplicates. Total flavonoid content was expressed as milligrams of quercetin equivalent per millilitre of the sample (mg QE/mL).

2.5.2. Total phenolic content

Total phenolic content (TPC) of coconut water in each variety was determined using the method specified by Singleton et al. (1999) with some modifications. Folin-Ciocalteu reagent was used to determine the total phenol content of the samples. Five millilitres of Folin-Ciocalteu reagent were measured into a beaker and 45 mL of distilled water was added to prepare ten-fold diluted solution. Preparation of 7.5 % Sodium carbonate was done by dissolving 7.5 g of Sodium carbonate in 100 mL of distilled water. For the stock solution preparation, 10 mg of Gallic acid was weighed and 1 mL of ethanol was added. Then the 200 µL of sample/standard solution series were mixed with I mL of Folin-Ciocalteu reagent. After two minutes, 1 mL of sodium carbonate solution was added into the mixture and was volumed up the content to 5 mL using distilled water. The sample/standard solution series were placed in dark for 120 minutes. The absorbance was measured at 765 nm UV visible spectrophotometer (HACH, DR 3900, Germany). Gallic acid standard curve was prepared by serially diluted gallic acid solution (500, 250, 125, 62.5, 31.25, 15.625, and 7.8125 µg/ml). Results were expressed as milligrams of Gallic acid equivalents per 100 mL of the sample (mg GAE/100 mL).

2.5.3. DPPH radical scavenging assay

1,1-Diphenyl-2-picrylhydrazl (DPPH) assay was assessed by using method suggested in Gulcin and Alwasel (2023) with some modifications. One millilitre of 0.1 mmol DPPH methanolic solution was added to 0.1 mL of extract of the sample or the standard solutions. Then, the solution was vortexed well and kept in dark for 30 minutes and optical density was taken at 517 nm by using UV visible spectrophotometer. The antioxidant capacity in the extracts was quantified by using a calibration curve constructed from different concentrations of Trolox standards solutions. Antioxidant activity was expressed as mmol Trolox equivalent per gram (Trolox mmol/g).

2.5. Data Analysis

All the readings were taken in triplicate and expressed as mean± SD. The data were statistically analysed by One-way ANOVA and Tuckey's post-hoc multiple comparison tests (confidence level- 95 %) using SPSS (Statistical Package for Social Sciences version 22.00) to evaluate and compare the comprehensive properties of the selected coconut varieties.

3. Results and Discussion

3.1. Physical properties of the selected coconut varieties

The physical properties of the coconuts such as the nut weight before and after dehusking, the length and the girth of nuts from each variety, and the volume, colour, specific gravity of the coconut water from each variety were measured, and the obtained data was summarized in the Table 1 and Table 2 respectively.

Table 1. Nut weight and nut circumference of six different coconut varieties

Variety	Nut weight (kg)		Nut circumference (cm)	
	Before dehusking	After dehusking	Length	Girth
Green dwarf	0.80±0.07^{d}	0.51±0.02^{b}	25.06±0.35^{c}	41.61±0.82^{d}
Red dwarf	1.13±0.15^{c}	0.56±0.03^{b}	25.78±0.69^{c}	45.83±1.36^{c}
Ran thambili	1.46±0.02^{ab}	0.76±0.02^{a}	32.00±0.00^{a}	56.39±0.42^{a}
Gon thambili	1.62±0.15^{a}	0.61±0.06^{b}	31.50±1.48^{a}	51.44±1.17^{b}
CRIC 60	1.21±0.11^{bc}	0.58±0.09^{b}	27.50±0.83^{bc}	27.50±0.83^{e}
CRIC 65	1.29±0.14^{bc}	0.65±0.07^{ab}	28.50±1.17^{b}	52.78±1.77^{b}

The values are mean ± SD of three replicates. Means with same superscript within the same column are not significantly different from each other (p>0.05).

As summarized in Table 1, the nut weight, length and the girth of the coconuts were found to be significantly differed (p<0.05) among the six varieties. The heaviest nut weight before dehusking was observed in *Gon thambili* (1.62±0.14 kg) while *Ran thambili* was the heaviest in weight after dehusking the nuts (0.76±0.02 kg). Green dwarf and red dwarf varieties comparatively have the lowest nut weights either with or without the husk. In addition, when compared with other tested varieties, the variety *Ran thambili* shows the highest nut circumference where the length is 32.00±0.00 cm, and the girth is 56.39±0.42 cm.

Nut weight (kg) and nut circumference (cm) of coconuts were varied among different coconut varieties and can indirectly influence the quality attributes of coconut water. These parameters provide useful information about varietal characteristics and maturity-related changes that may affect the physicochemical composition and overall quality of coconut water.

Siriphanich et al. (2011) has stated that a mature fruit weights between 1 to 2 kg which is a significant decrease from 3 to 5 kg at its optimum weight at about nine months. The dimensions of mature fruits are 15-20 cm in diameter and 20-30 cm in length. Fruits from tall cultivars are usually larger than those from dwarf cultivars. The mean values of nut circumference in the current study are not in accordance with the study which has mentioned above. The reason for this may be due to the differences in the localities in which each study has been conducted and also the stage of maturity of the coconuts.

Table 2. Physical properties of coconut water of six different varieties

	Green dwarf	Red dwarf	*Ran thambili*	*Gon thambili*	CRIC 60	CRIC 65
L*	24.10±0.58[a]	22.36±0.52[a]	22.84±1.93[a]	24.19±0.61[a]	21.81±0.64[a]	24.50±1.38[a]
a*	9.25±2.82[a]	9.72±0.72[a]	8.61±1.00[a]	10.05±0.47[a]	8.28±0.23[a]	8.00±0.44[a]
b*	3.67±1.32[a]	2.29±0.61[a]	2.30±1.15[a]	2.89±1.38[a]	1.84±0.16[a]	2.55±0.25[a]
Whiteness index	23.42±0.17[a]	21.72±0.44[a]	22.33±1.99[a]	23.47±0.72[a]	21.35±0.66[a]	24.04±1.41[a]
Specific gravity	1.03±0.01[ab]	1.02±0.04[ab]	1.02±0.02[ab]	1.02±0.01[ab]	0.96±0.01[b]	1.07±0.00[a]
Water volume (mL)	137.22±2.27[ab]	162.33±7.84[ab]	217.78±4.44[a]	189.67±40.88[ab]	108.67±17.18[ab]	158.78±27.91[b]

The values are mean ± SD of three replicates. Means with same superscript within the same column are not significantly different from each other (p>0.05).

A significant difference was observed in the specific gravity of the water of different coconut varieties as shown in Table 2. Variety CRIC 65 (1.07 ± 0.00) has comparatively the specific gravity in water content. According to Pummer et al. (2001) coconut water has a specific gravity of about 1.02 which supported with the results from the current study.

A significant difference was observed in the volume of coconut water contained in six different coconut varieties tested. As shown in Table 2, *Ran thambili* contains the highest volume (217.78 ± 4.44 mL) of coconut water compared to the other varieties. These results are also in accordance with those of nut circumference and nut weight where *Ran thambili* which gave the highest nut weight after dehusking.

Jackson et al. (2004) has stated that as the nut matures, the liquid endosperm increases its water-holding capacity, generating internal pressure. Consequently, the developing kernel partially replaces the liquid endosperm to relieve this pressure.

The colour parameters of the coconut water of six coconut varieties were also examined and the obtained results are summarized in the Table 2. The L* value represents lightness (ranging from black to white), a* indicates the red–green axis, and b* represents the yellow–blue axis of the colour space. There was no significant difference (p>0.05) between the mean values of the colour parameters (L*, a*, b*) and the whiteness index of water obtained from six varieties as shown in Table 2.

The whiteness index is a quantitative measure that combines yellow-blue and lightness into one term to represent the degree of whiteness (Milovanovic et al. 2020). Although there is no significant difference between the values under whiteness index, showed a slightly higher mean value was observed in CRIC 65 variety resembling that coconut water from variety CRIC 65 was lighter in colour compared to that of other tested varieties.

3.2. Chemical Properties of the Selected Coconut Varieties

Table 3. Chemical properties of coconut water obtained from six varieties.

Variety	pH value	Total soluble solids (°Bx)	Titratable acidity
Green dwarf	6.95±0.03^{a}	3.72±0.37^{ab}	0.29±0.07^{a}
Red dwarf	6.73±0.05^{b}	3.20±0.44^{b}	0.36±0.13^{a}
Ran thambili	6.34±0.06^{c}	4.20±0.20^{a}	0.51±0.26^{a}
Gon thambili	6.25±0.06^{c}	4.53±0.11^{a}	0.55±0.15^{a}
CRIC 60	5.47±0.10^{d}	4.43±0.46^{a}	0.37± 0.05^{a}
CRIC 65	5.15±0.04^{e}	4.23±0.38^{a}	0.62±0.08^{a}

The values are mean ± SD of three replicates. Means with same superscript within the same column are not significantly different from each other (p>0.05).

As per the results in Table 3, a significant difference (p<0.05) was observed in the mean pH values among the tested coconut water samples. The water samples from CRIC 60 and CRIC 65 varieties had showed comparatively lower pH of 5.47 ± 0.11 and 5.15 ± 0.04 respectively. Other varieties were shown values closer to neutral pH, indicating that the coconut water from those varieties was neither acidic nor basic. The majority of studies found that the pH of coconut water increases with maturity (Kumar et al*.* 2021).

As it is summarized in Table 3, the total soluble solids (of the coconut water samples were found to be significantly different among the six varieties. The highest total soluble solid content of 4.53 ± 0.11 °Bx was observed in the water obtained from *Gon thambili* variety. In contrast the coconut water of two dwarf coconut varieties was found to have relatively less total soluble solid contents. The observed differences in the total soluble solids between the various coconut varieties reflect significant variations in the sugar content of mature coconut water. Significantly higher total soluble solid content was observed in CRIC 60 (4.43 ± 0.46°Bx) and *Gon Thambili* (4.53 ± 0.11°Bx) when compared to the other types, suggesting possible variations in sweetness levels. Total soluble solid contents in young coconut water rose from 5.39 to 6.76 °Bx in the immature stage, then gradually increased to 7.45 °Bx at the end of the mature stage, and kept on rising at a slightly higher rate to 8.24 °Bx at the end of the overmature stage (Azra et al. 2021).

The titratable acidity of the samples was expressed as a percentage of citric acid, since citric acid is the predominant type of organic acid present in coconut water. Generally, in past studies, the titratable acidity of coconut water was expressed in terms of citric acid and malic acid (Aroucha et al. 2010). As shown in Table 3, there was no significant difference (p>0.05) in the titratable acidity among the six varieties of coconut water. Compared to the results obtained in this study, the coconut varieties with high pH values are having lower values for titratable acidity which also supported those of the findings of Jackson et al. (2004). Reduced levels of organic acids and ascorbic acids in the nut water with maturity might be the reason behind the decrease in titratable acidity (Kumar et al. 2021).

3.3. Nutritional Properties of Six Coconut Varieties

Table 4. Nutritional properties of the water obtained from six coconut varieties

	Green dwarf	Red dwarf	*Ran thambili*	*Gon thambili*	CRIC 60	CRIC 65
Ash %	1.30±0.65^{a}	0.79±0.08^{a}	0.88±0.29^{a}	0.73±0.08^{a}	0.65±0.43^{a}	0.69±0.07^{a}
Protein %	0.78±0.25^{a}	0.59±0.39^{a}	0.32±0.06^{a}	0.45±0.06^{a}	0.29±0.09^{a}	0.20±0.04^{a}
Fat %	0.03±0.00^{b}	0.07±0.01^{b}	0.03±0.01^{b}	0.05±0.02^{b}	0.18±0.02^{a}	0.18±0.06^{a}
Total sugars (g/100 mL)	2.89±0.67^{a}	3.09±0.29^{a}	3.03±1.29^{a}	3.54±0.52^{a}	2.90±0.26^{a}	2.01±0.61^{b}
Potassium (mg/L)	425.4±34.8^{bc}	793.0±108.7^{a}	654.7±43.5^{ab}	518.4±58.0^{bc}	344.3±43.5^{c}	854.5±21.7^{a}
Sodium (mg/L)	147.1±26.0^{a}	91.9±52.0^{a}	110.3±26.0^{a}	128.7±52.0^{a}	110.3±26.0^{a}	73.5±26.0^{a}

The values are mean ± SD of three replicates. Means with same superscript within the same column are not significantly different from each other (p>0.05).

The nutritional components such as proteins, fat, total sugar and ash were determined, and the obtained results are summarized in Table 4. The ash content of coconut water, indicative of the mineral composition, has not been exhibited significant variations among different varieties considered. Also, the protein content of coconut water samples has not significantly differed among the six varieties. According to Wynn (2017), there's only a small number of proteins present in coconut water at both mature and immature stages compared to that of the coconut kernel at mature and immature stages. Further according to Wynn (2017), the protein content of immature and mature coconut water is 0.66 and 0.81 % respectively and as per the results of the current study, the protein content of 11 months mature coconut also varied in a range of 0.20 ± 0.04 to 0.78 ± 0.25 %. With the maturation, the coconut meat gradually increases in nitrogen and total protein content (Wynn 2017). Coconut water is a good source of amino acids while prolamin, glutelin, albumin, and globulin are the main proteins in coconut water (Rajamohan & Archana 2018).

There was a significant difference in fat content among the six coconut varieties, while the improved varieties of coconuts including CRIC 60 and CRIC 65 were having relatively high fat content compared to the local varieties. According to Coulibaly et al. (2023), the average values of fat contents ranged between 0.17 ± 0.21 and 0.33 ± 0.02 % among the tall, dwarf and mixed (street) coconut water samples tested and as per the results of the current study, the fat content of the six varieties varied in a range of 0.03 ± 0.00 to 0.18 ± 0.06 % where the results of the current study are less than the reported values.

As mentioned by Kwiatkowski et al. (2008), Aurantiaca (king coconut) varieties are found to be containing high sugar content of 5-7 % which indicates a sweetened taste in both water and kernel. However, according to the results of the current study, the total sugar content of all tested varieties varied in a range of 2.01 ± 0.61 to 3.54 ± 0.52 g/100 mL indicating the coconut water of all varieties are comparatively less sweet. Jayasinghe et al. (2023) has highlighted that detecting the specific sugar forms appears to be useful in determining the most suitable harvesting stage. As shown in Table 4 total sugar content exhibited a significant difference for all varieties analysed. The mean values of total sugars obtained through analysis were remained in the range as in previous research study for mature coconut water (Jackson et al. 2004). According to Jackson et al. (2004) coconut water of green dwarf variety at the maturity stage of eighth month had 5.98% of sugar content compared to other varieties analysed.

The mineral constituents and their salts support the maintenance of the body system's acid-base equilibrium (Njoku & Ohia 2007). It has been found that both coconut water and kernel are rich in minerals such as K^+, Na^+, Ca^{2+}, Mg^{2+}, and Zn^{2+}. Many studies revealed that, Potassium is the predominant mineral in coconut water (Kwiatkowski et al. 2008) and in addition, studies have discovered that coconut water contains inorganic ions such as Cl^-, PO_4^{3-} and SO_4^{3-} (Richter et al. 2005). The mean values of Potassium and Sodium concentrations present in coconut water of six different varieties are summarized in Table 4. There was a significant difference (p<0.05) in the Potassium content of coconut water among six varieties analysed while the Sodium contents were not significantly different. CRIC 65 showed the highest K^+ content (854.5 ± 21.7 mg/L) among the studied varieties. Previous studies have also reported that coconut water contains relatively high levels of K^+ compared to the six varieties analysed in this study. As in the findings of Kannangara et al. (2018) the limits of Potassium level in coconut water were found to be 299.06 ± 14.32 mg/100 mL and with maturity, the Potassium content increases gradually as the volume of water declines. Prades et al. (2012) have revealed that this difference could be due to use of different farming practices, fertilizers and manure applied to the coconut tree orchards. Sodium concentrations of six different varieties determined in this study were higher than the values found by Kwiatkowski et al. (2008), which is in the range of 30.05 to 37.45 mg/L, for the water obtained from coconuts of 6 to 9 months. Costa et al. (2006) has found that the sodium contents were varied from 31.41 to 96.36 mg/L for the coconut water of yellow dwarf variety which are in the maturity stage of 5-8 months. In the current study, the sodium content of the tested coconut water ranged from 73.5 ± 26.0 to 147.1 ± 26.0 mg/L.

3.4. Functional Properties of Six Coconut Varieties

Table 5. Functional properties of the water samples of six coconut varieties

Variety	Total Phenol Content (TPC) (mg GAE/100mL)	Total Flavonoid Content (TFC) (mg QE/mL)	Antioxidant capacity (mg Trolox/g)
Green dwarf	6.44±3.24[a]	0.05±0.03[b]	7.59±0.51[ab]
Red dwarf	6.70±1.82[a]	0.21±0.02[a]	4.47±1.89[bc]
Ran thambili	5.87±3.02[a]	0.07±0.03[b]	2.46±1.61[c]
Gon thambili	7.85±2.58[b]	0.26±0.06[a]	5.12±1.93[bc]
CRIC 60	6.83±2.99[a]	0.06±0.04[b]	8.06±0.92[ab]
CRIC 65	6.57±3.11[a]	0.03±0.01[b]	10.51±1.10[a]

The values are mean ± SD of three replicates. Means with same superscript within the same column are not significantly different from each other (p>0.05).

Phenolic compounds could scavenge free radicals by acting as hydrogen donors and reducing agents (Phuyal et al. 2020). As shown in the Table 5, the TPC varied significantly across the six different varieties of coconut water (p<0.05). *Gon thambili* had the highest TPC (7.85 ± 2.58 mg GAE/100 mL) while *Ran thambili* had the lowest TPC (5.87 ± 3.02 mg GAE/100 mL). The TPC content of coconut water determined by Mahayothee et al*.* (2016), was in the range of 5.18 mg GAE/100 mL to 7.17 mg GAE/100 mL, which is compatible with that of the values obtained in the current study.

Generally, the phenolic compounds in coconut water are lower than those in the coconut kernel (Mahayothee et al. 2016). Watawana et al. (2016) has stated that coconut water possesses 43 phenolic compounds such as catechin, salicylic acid and few amounts of caffeic, p-coumaric acids and ferulic.

The total flavonoid content (TFC) of the coconut water samples analysed were significantly differed between the six varieties of coconuts (p<0.05). The highest TFC was observed in the coconut water from *Gon thambili* variety (0.26 ± 0.06 mg QE/mL) while the lowest was in CRIC 65 (0.028 ± 0.012 mg QE/mL). Farooqui and Farooqui (2018) has stated that flavonoids have beneficial effects against cancer, cardiovascular disease, viral and bacterial infections, and other infectious diseases.

Coconut water possesses micronutrients such as vitamins that are having a direct impact on human body through either scavenging of free radicles that might cause damage to body cells or increasing the indirect production of antioxidant enzymes including catalase, peroxidase, glutathione by eliminating harmful radicles (Agbafor et al. 2015). Mantena et al. (2003) has mentioned that the antioxidant properties of coconut water are considerably reduced when subjected to heat treatments or due to the activity of acids / alkaline on coconut water and with the maturity stage of coconuts. There was a significant difference among the antioxidant capacities of six different varieties of coconut water samples analysed in this study. As shown in table 5, CRIC 65 contained the highest antioxidant capacity (10.51 ± 1.10 mg Trolox/g) compared to other varieties while lowest antioxidant capacity was present in the water of *Ran thambili* (2.47 ± 1.61 mg Trolox/g). Coulibaly et al. (2023) has obtained values for antioxidant capacity of coconut water of tall, dwarf and street varieties as 15.84 ± 1.76, 40.15 ± 3.18 and 65.14 ± 0.00% respectively. In the study of Santos et al. (2013) which has studied the antioxidant capacity of coconut water of several varieties, showed that all the varieties revealed the ability to scavenge DPPH free radical and the best antioxidant capacity could be observed in green dwarf variety with an IC_{50} of 150 μg/mL DPPH.

4. Conclusions

As conclusion, this study revealed clear differences in the nutritional, physicochemical, and functional properties of coconut water among selected traditional and improved Sri Lankan coconut varieties. Key findings include consistently higher potassium than sodium levels across all varieties, high total phenol and flavonoid contents in *Gon thambili*, and high antioxidant activity in CRIC 65. These findings proved that coconut water is a valuable nutritional and functional drink and they also provide insights for consumers seeking healthy beverage options and offer producers and researchers information to optimize processing and promote the utilization of this underused natural resource.

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