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Physicochemical properties and sensory acceptability of different varieties of coconut water and flesh

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ABSTRACT

Coconut water is a sweet and refreshing drink obtained directly from the immature coconut and its flesh is smooth with a jelly-like structure. In spite of physicochemical properties of coconut water, its sensory characteristics are not much studied. This study was carried out to evaluate the physicochemical properties and sensory acceptability of different varieties of coconut water and flesh. The varieties of coconut used in this study were tall, dwarf, and hybrid coconut. Firstly, the weight of the coconuts were determined in which the tall variety was the heaviest coconut compared to the others. Tall coconut also showed a significantly higher amount of water volume and weight of coconut flesh. The dwarf coconut water revealed the highest pH (5.48± 0.02) with the lower titratable acidity (0.045±0.01 %). The highest total soluble solid (4.97±0.15 °Brix) was found in tall coconut. The fructose and glucose content of coconut water of all varieties were found in a range of 2.70-3.58% and 2.04-3.24%, respectively. Potassium was the most abundant mineral in all coconut samples in which a larger quantity was found in the water of tall coconut and flesh of the dwarf coconut. The Folin–Ciocalteu method showed that dwarf coconut water (9.07±0.00 mg GAE/100 ml) and hybrid coconut flesh (11.57±0.34 mg GAE/100 g) had higher phenolic content than the others. Hybrid coconut flesh exhibited the lowest crude fat content (18.33±1.22 %) than others. Meanwhile, dwarf and hybrid coconut water were more acceptable and appreciated in taste, sweetness, sourness, and overall acceptability. Although the tall coconut flesh was the least acceptable in taste and texture, all samples' overall acceptability was *acceptable. In conclusion, dwarf and hybrid coconut have a big potential to produce high-quality beverages and have a good quality of flesh.*

Keywords: coconut water; coconut flesh; dwarf coconut; hybrid coconut; tall coconut

INTRODUCTION

Coconut (*Cocos nucifera* L.) is grown in many countries, which are mainly cultivated in Indonesia, Philippines, India, Malaysia, Sri Lanka, Mexico, and some of the islands in Oceania [1]. In Malaysia, coconut plantation ranked fourth important industrial crop after oil palm, rubber and paddy in terms of total planted area [2]. According to the Department of Agriculture, there is a great increase in the term of production wherein 2014, Malaysia produced 535,587 metric ton and rose to 603,328 metric ton in 2018 [3]. The most states that grew the coconut in 2014 were Johor (13,134 ha), Selangor (9,519 ha), Perak (9,384 ha), Sarawak (16,983 ha), and Sabah (17,202 ha) [4].

Coconut is among the most useful trees and is described as “the tree of life”, “tree of heaven,” or “tree of abundance,” as most parts of the tree are beneficial to produce either food or non-food products. Coconut water, coconut milk and coconut oil are among the main target food products derived from coconut trees. Coconut water is one of the most popular beverages in the world as it is known as an ancient tropical beverage and low in caloric value. Coconut water is luxurious in terms of nutrient content, including salts and minerals, such as potassium, sodium, chloride, magnesium, sugars and B vitamins [5,6,7]. It has low fat content and a trace amount of protein [6]. Potassium is the major mineral in coconut water and sodium being the next [8]. Compared to commercialized isotonic drinks, coconut water has demonstrated to have hydration effects similar to carbohydrate-electrolyte sports drinks which make it as suitable as ergogenic drinks [5]. Previous study also suggested usage of coconut water as a natural alternative and viable option to replace and replenish the loss of glucose when exercising for a prolonged amount of time compared to water alone [9].

Different varieties of coconut that are suitable for drinks planted in

Malaysia include the tall, dwarf and hybrid variety. Some examples of tall variety are Malayan Tall and West African Tall, while the dwarf varieties include aromatic dwarf (PDN), Malayan Red Dwarf (MRD), Malayan Yellow Dwarf (MYD) and Malayan Green Dwarf (MGD). A cross-breeding of tall and dwarf coconut, hybrid coconut, had been developed to improve the nut yield and tender nut qualities. MATAG (MYD/MRD x Tagnanan Tall) and MAWA (MYD x West African Tall) are two common varieties of hybrid coconut planted in Malaysia [10]. Quality criteria such as total soluble solid (TSS), total sugar and potassium content are good indicators for estimating the suitability of coconut varieties for the production of commercial coconut water beverage. The composition of raw coconut water is determined by a range of factors including growing region, which influences soil, environmental conditions, fertilizer application, variety and cultivar, and the stage of maturity at harvesting [11]. Relationship of sugar content and sensory attributes would give a good indicator in order to characterize specifically coconut water and for their efficient promotion.

In general, coconut water is taken as a naturally refreshing drink by people worldwide including Malaysia because of its pleasant taste, sweet aroma and nutritional content. The demand is increasing not only due to its sensory properties but also due to its nutritional properties. Coconut water, a sweet and refreshing drink, is obtained directly from the coconut, commonly at its immature stage and enjoyed with its flesh that is smooth and jelly-like in texture. The data of physicochemical properties and the sensory acceptability of coconut water from the different varieties of coconut available in Malaysia, especially its flesh, is still limited. Therefore, the present work was aimed to evaluate the chemical composition, physical properties, and sensory acceptability of coconut water and flesh collected from different varieties of immature coconut.

MATERIALS AND METHODS

Sample preparation: Immature coconut fruits (N=30) of three different varieties were collected from Pusat Pertanian Parit Botak, Senggarang, Batu Pahat, Johor. The types of coconut fruits used were tall coconut (Malayan Tall), aromatic dwarf coconut (PDN) and hybrid coconut (MATAG). Immature coconuts were selected at 5-6 months old and contained soft-thin jelly-like coconut flesh. The surface of the nuts was dehusked and cleaned with distilled water before a stainless-steel knife was used to perforate the fruit mesocarp. Coconut water was extracted from the coconut fruit and filtered through a muslin cloth. The filtered coconut water obtained from several fruits (10 coconuts with similar maturity age) was pooled in bottles. The white flesh was scooped by a stainless-steel spoon with extra precautions not to scrape off the testa. The water and the flesh of the three varieties of coconut fruits were separately pooled (after weight and volume measurement) to form a composite sample. All coconut water and flesh that had been prepared were stored at -20 °C prior to analysis. Sample preparations were conducted in triplicate.

Physical analysis: The weight and volume of water of each individual coconut fruit was determined using digital balance and measuring cylinder, respectively. In similar manner, the weight of white flesh of individual coconut fruit was recorded. A 100 g samples were collected from composite sample for determination of total soluble solid (TSS), pH and titratable acidity (TA). The TSS was measured with a benchtop ABBE refractometer and expressed as ºBrix. The pH of coconut water was determined using a pH meter (Hanna instrument, HI 2211 pH/ORP). Titratable acidity of coconut water was determined using the AOAC method of titratable acidity in wine or juice method [10]. The final percentage was expressed as % malic acid (w/v).

Chemical analysis: The sugar content of coconut water was determined using the normal-phase High-Performance Liquid Chromatography (HPLC) (Waters, USA) method with a refractive index detector (Waters 2414, USA). The chromatographic separations were achieved using Waters Sugar-Pak 1 column with 20 µL injection volume. The mobile phase consisted of acetonitrile, and water (90:10) was pumped through the system at a flow rate of 1.5 ml/min at isocratic gradient. Two major types of sugar, namely glucose and fructose, were identified by comparing the retention time of the sample with the sugar standards. A calibration curve for each sugar was plotted in concentrations ranging from 1 % to 6 %. Selected mineral compositions (potassium, sodium, calcium and magnesium) were determined for both coconut water and flesh. The organic compounds of coconut flesh were digested by using nitric acid and hydrogen peroxide. The determination of mineral contents in diluted samples was carried out in ICP OES (Optima DV

2100, Perkin Elmer, USA) in triplicates. The calibration curves were plotted in the software based on the measurements of ICP multi element standard and compared with the concentration for all the elements in the sample. Total phenolic content (TPC) in coconut water and flesh was determined using Folin Ciocalteu method with some modifications [12]. Coconut water was diluted with distilled water prior to the addition of Folin-Ciocalteu reagent while the lyophilized coconut flesh was extracted with methanol (1:5 w/v) incubated for 3 h at 50 ºC. The sample extracts were diluted with distilled water before mixed with Folin Ciocalteu's reagent (1 mL) and allowed to react for 3 minutes. Sodium carbonates of 0.8 mL (7.5 % w/v) were added to the mixture and incubated at room temperature for 2 hours. Measurement of absorbance (765 nm) of both incubated mixture of coconut water and flesh were carried out in a UV visible spectrophotometer (Shimadzu UV 1601PC, Japan). TPC of coconut water and flesh was expressed as gallic acid equivalents (GAE) per 100 mL water and 100 g fresh meat. Lyophilized coconut flesh was also analyzed for its crude fat content using the Soxhlet extraction method [13].

Sensory acceptability: Acceptability test was conducted using a 9-point hedonic scale with thirty untrained panelists to evaluate the appearance, aroma, sweetness, sourness, taste and overall acceptability of coconut water. Additionally, attributes of appearance, texture, taste and overall acceptability were determined for coconut flesh. Sample of coconut water and flesh were presented separately, where coconut water was poured into cups while the coconut flesh was placed onto plates. In order to preserve the aroma, the coconut water was poured into the non-odorous bottle immediately right after the coconut water was extracted from the coconut and closed the bottle cap tightly. The sensory panelists were given a brief information and instruction prior to the sensory evaluation. All samples were coded using random numbers and arranged according to permutation numbers.

Data analysis: All the data from each sample in the analysis was in triplicate. The data was expressed as means ± standard deviation (n=3). Then, the data was analysed by using one way Analysis of Variance (ANOVA) in the IBM SPSS (version 20) software. Duncan's new multiple range test was used to analyse the significant differences ($p < 0.05$) between the means.

RESULTS AND DISCUSSION

Physical properties of coconut water and flesh: Quality parameters of coconut fruits mainly determined by its physical properties. Table 1 presents the quality attributes of coconut water and flesh of different coconut varieties. The tall coconut showed the greatest weight, followed by hybrid coconut and dwarf coconut ($p<0.05$). Previous studies reported that tall coconut usually weighed about 3 kg [14]; however, in the most recent study showed the weight was lesser in the range of 1.8 to 2.1 kg [15]. The average mass reported by [16] demonstrated that tall coconut was heavier (1.99 kg) compared to hybrid coconut (1.15-1.62 kg).

In terms of volume, tall coconut yielded significantly higher coconut water volume (701.10±157.58 mL) followed by hybrid (551.70±156.91 mL) and dwarf (303.40±27.27 mL). Previous work demonstrated that immature coconut could produce a high yield of water volume, while tall coconut produces the highest [12] and dwarf produce the lowest [5,17]. As expected, the physical attributes of the hybrid coconut water were intermediate [5,18] since MATAG is a crossbreed between tall (Tagnanan) and local dwarf cultivar (MYD/MRD). However, as compared to the literature, a slight variation in the yield of water volume was observed, which could be affected by drought season as claimed by the previous study [19]. In the same way, tall coconut also provides a significantly higher yield of coconut flesh, comparable to its fruit weight and water volume. Even the weight of coconut fruit is barely mentioned in the publications; it is one of the important criteria for the estimation of water to nut ratio (%v/w). This quality parameter is a major indicator for the evaluation of the transportation cost for the field to the processing area and helps to determine the amount of waste which consists of green husk and shell produced through the processing or consumption of immature coconut.

Table 1: Physical properties of coconut water and flesh

Properties	Coconut variety		
	Tall (Malayan Tall)	Dwarf (PDN)	Hybrid (MATAG)
Weight of coconut (kg)	3.72±0.25 [a]	1.70±0.20 [c]	2.75±0.28 [b]
Volume of water (ml)	701.10±157.58 [a]	303.40±27.27 [c]	551.70±156.9 [b]
Weight of flesh (g)	232.00±101.99 [a]	93.50±13.13 [c]	201.50±42.50 [b]
Total soluble solid (ºBrix)	4.97±0.15 [a]	4.40±0.17 [b]	4.67±0.12 [b]
Titratable acidity (%)	0.063±0.0 [a]	0.045±0.01 [b]	0.058±0.01 [a,b]
pH	5.36±0.01 [b]	5.48±0.02 [a]	5.25±0.01 [c]

Values show mean ± standard deviation (n=3). Values with different subscripts of small letters in the same row indicated the significant difference (p<0.05) between varieties of coconut.

It has been computed from the literature that the water/nut ratio ranged between 14–26 % [18]. Prior studies reported that the % water/nut ratio of hybrid (MATAG) was 20.20 % [5] which is in agreement with current findings. A slight variation on the yield of coconut water volume and weight of flesh could be due to the maturation stage, soil, and climate condition [17].

Total soluble solids in coconut water mainly dominated by sugar presence. It can be used as a simple measurement to indicate the sweetness level of coconut water. The TSS of coconut water obtained from the tall variety was significantly higher than that of dwarf and hybrid variety ($p<0.05$). It has been reported that coconut water is composed of 5-8 % of total soluble solids with minor components of amino acids, organic acids and minerals [20]. Current findings reported slightly lower TSS values compared to [5,6]; however, based on findings of [17], the TSS could be affected by the time the coconut was harvested. It was shown that the initial TSS of coconut harvested at aged 5-6 months have low value as it will continue to increase until it reached 9-10 months of maturation, thereafter TSS slightly decreased at 11-12 months.

The pH value of coconut was slightly varying according to the coconut variety. In Table 1, dwarf coconut has a significantly higher pH and followed by tall coconut and hybrid coconut. Overall, all varieties of coconut water were classified as slightly acidic beverages, which was in agreement with previous studies [5,6,17,18,20]. As indicated in Table 1, the titratable acidity (TA) of coconut water was found to be in the range of 0.045-0.063 % malic acid equivalent. Titratable acidity in this study was expressed as the malic acid percentage since malic acid is the main organic acid in the coconut water. Findings of this study showed that the tall coconut has the highest organic acids presence while the lowest value of titratable acidity was dwarf coconut. This finding is in agreement with [12,17,20] which observed that regardless of varieties, titratable acidity in immature coconut water was the highest compared to mature coconut water.

Chemical composition of coconut water and flesh: The chemical composition of coconut water and flesh is presented in Table 2 and Table 3. The sweetness of coconut water, is contributed by the presence of naturally occurring sugar. Fructose is known to contribute to a higher degree of sweetness compared to other types of sugar [21]. The highest amount of fructose was measured in dwarf coconut (3.58±0.11 %) and the lowest was in tall coconut (2.70±0.01 %). In contrast with fructose, dwarf coconut contains significantly lower amount of glucose while hybrid coconut provides the highest value of 2.04±0.13 % and 3.20±0.07 %, respectively. Previous findings stated there are three types of sugars commonly found in coconut water, namely fructose, glucose and sucrose [14]. However, in the present study, only fructose and glucose could be quantified while only trace of sucrose could be detected in green immature coconut water. This result may be explained by the fact that sucrose is highly concentrated in matured coconut water than the young ones [5,12].

Table 2: Chemical properties of coconut water

Properties	Coconut variety		
	Tall (Malayan Tall)	Dwarf (PDN)	Hybrid (MATAG)
Fructose (%)	2.70±0.01 c	3.58±0.11 a	3.13±0.04 b
Glucose (%)	2.83±0.04 b	2.04±0.13 c	3.20±0.07 a
Sucrose (%)	n.d.	Trace	n.d.
Potassium (mg/L	1053.30±4.76 a	528.50±18.79 c	618.03±19.78 b
Sodium (mg/L)	43.27±54.43 c	54.43±0.31 b	64.00±2.29 a
Calcium (mg/L)	64.60±0.17 b	42.80±0.95 c	77.50±0.35 a
Magnesium (mg/L)	58.20±2.00 b	64.43±0.55 a	37.73±1.29 c
Total phenolic content (mg GAE/100 mL)	6.04±0.23 c	9.07±0.31 a	7.67±0.75 b

Values show mean ± standard deviation (n=3). Values with different subscripts of small letters in the same row indicated the significant difference ($p<0.05$) between varieties of coconut. n.d.= not detected

Table 3: Chemical properties of coconut flesh

Properties	Coconut variety		
	Tall (Malayan Tall)	Dwarf (PDN)	Hybrid (MATAG)
Crude fat (%)	22.29±1.67 a	25.08±0.60 a	18.33±1.22 b
Potassium (mg/L)	12.91±0.26 c	23.69±0.28 a	15.49±0.32 b
Calcium (mg/L)	3.20±0.11 b	3.81±0.10 a	3.53±0.13 a
Magnesium (mg/L)	3.75±0.15 b	4.28±0.29 a	3.81±0.10 b
Total phenolic content (mg GAE/100 g FW)	8.77±0.27 c	9.70±0.50 b	11.57±0.34 a

Values show mean ± standard deviation (n=3). Values with different subscripts of small letters in the same row indicated the significant difference ($p<0.05$) between varieties of coconut.

Sugar profiles are varied throughout the ripening process which sucrose starts to appear in coconut water at the age of 6 to 8 months and when the coconut reaches its full maturity the reducing sugars (fructose and glucose) in water were mainly replaced by sucrose [18]. This also accords to earlier findings which showed that young MATAG and young Malayan Tall coconut water contain small concentrations of sucrose 0.54±0.11 g/100 mL sucrose and 0.14±0.05 g/100 mL, respectively [5,6].

Crude fat content was only quantified in coconut flesh samples (Table 3). Hybrid flesh contains a lesser amount of crude fat content than tall and dwarf variety ($p<0.05$). This finding is in line with results reported in aromatic coconut flesh by [20] which stated at the age of 7 months coconut flesh can reach up to 24 % fat content. In another study, crude fat content in tender coconut kernels may vary from 37.3 % to 50.2 % [9].

Minerals could help in maintaining the acid-base balance of the human body system. Coconut water is known to be a good source of electrolyte minerals. Table 2 and Table 3 demonstrate selected minerals content present in coconut water and coconut flesh, respectively. Comparing all varieties of coconut tested, potassium content was the most abundant mineral recorded both in water and flesh. Coconut water from tall coconut provides a significantly higher potassium, followed by hybrid and dwarf ($p<0.05$). In contrast, flesh of dwarf variety contains highest in potassium and the least amount found in tall coconut. However, mineral contents are difficult to compare among varieties and they are strongly dependent on cultivation practices and particularly on the fertilizers or manure applied to coconut palm orchards [18]. Other minerals such as sodium, calcium and magnesium were also present in the sample tested but in lesser amounts. This finding in the current study is consistent with data reported earlier by another researcher [5,6,8,12,18].

Both coconut water and flesh were found to contain total phenolic content (TPC), whereby the dwarf variety provides the highest amount of TPC in its water while the highest amount of TPC of flesh is provided by hybrid variety. The results obtained in the current study are slightly higher than previously reported on tall coconut water obtained in Penang (5.4 mg GAE/100 mL) [10] but lower compared to [6]. For the coconut flesh, the highest TPC was obtained in hybrid coconut (11.57 mg GAE/100 g FW) followed by dwarf coconut (9.70 mg GAE/100 g FW) and the tall coconut (8.77 mg GAE/100 g FW). Overall, coconut flesh provided a higher amount of TPC than the coconut water and this result is in agreement with [20].

Sensory acceptability of coconut water and flesh: The acceptance of coconut water and flesh were determined by thirty untrained panelists consisting of staff and students of Faculty of Applied Sciences, Universiti Teknologi MARA. As stated in Table 4, no significant difference in appearance acceptability among all varieties of coconut water. However, the aroma of dwarf coconut water is significantly higher compared to tall coconut water. This could be due to the presence of an aromatic compound known as 2-acetyl-1-pyrrolinein that is contributed to the fragrance note similar to pandan leaves and jasmine rice [22]. Sensory panelists showed similar acceptability between dwarf and hybrid coconut water. These varieties of coconut water received a higher mean score between 6-7 (slightly like to moderately like) in most of the sensory attributes (taste, sweetness, sourness and overall acceptability) as compared to tall coconut variety received mean score of 5-6 (neither like nor dislike to slightly like). Higher sweetness scores in hybrid and dwarf coconut probably correlated with higher fructose content found in both coconut water samples. Previous research discovered that the dwarf coconut is the most appreciated in the term of taste and sweetness compared to hybrid and tall coconut [23]. The sensory quality of coconut flesh was evaluated based on appearance, taste, texture and overall acceptability. A similar trend was observed in the sensory evaluation of coconut flesh. Despite no significant difference being shown for appearance attributes, higher scores were given for all attributes to both hybrid and dwarf varieties as compared to tall varieties.

Table 4: Sensory acceptability of coconut water

Sensory attributes	Coconut variety		
	Tall (Malayan Tall)	Dwarf (PDN)	Hybrid (MATAG)
Appearance	6.37±1.35 [a]	6.93±1.39 [a]	7.00±1.20 [a]
Aroma	5.27±1.41 [b]	6.47±1.72 [a]	5.80±1.35 [a,b]
Taste	6.00±1.41 [b]	7.13±1.41 [a]	7.10±1.37 [a]
Sweetness	5.67±1.35 [b]	7.10±1.30 [a]	6.77±1.36 [a]
Sourness	5.50±1.61 [b]	6.33±1.58 [a]	6.43±1.52 [a]
Overall	6.23±1.25 [b]	7.27±1.14 [a]	6.97±1.27 [a]

Values show mean ± standard deviation (n=30). Values with different subscripts of small letters in the same row indicated the significant difference ($p<0.05$) between varieties of coconut.

Table 5: Sensory acceptability of coconut flesh

Sensory attributes	Coconut variety		
	Tall (Malayan Tall)	Dwarf (PDN)	Hybrid (MATAG)
Appearance	5.57±1.87 [a]	6.03±1.61 [a]	6.33±1.63 [a]
Taste	5.07±1.76 [b]	6.87±1.53 [a]	6.03±1.63 [a]
Texture	5.10±1.81 [b]	7.10±1.53 [a]	6.13±1.61 [a]
Overall	5.53±1.89 [a]	6.37±1.50 [a]	6.30±1.53 [a]

Values show mean ± standard deviation (n=30). Values with different subscripts of small letters in the same row indicated the significant difference ($p<0.05$) between varieties of coconut.

CONCLUSION

In conclusion, the highest water and flesh yield were collected from the tall coconut. The tall coconut also provides the highest amount of potassium, while dwarf coconut water is rich in fructose and total phenolic content. The flesh of coconut can be consumed together with water as it provides a significant amount of minerals and phenolic content but should be in moderate serving size since it also contains fat. Despite the highest water and flesh yield from tall coconut, dwarf and hybrid coconut are preferred (moderately like) by the panelist based on the sensory acceptability score. Hence, producers, manufacturers, and consumers may select an appropriate variety of coconuts depending on their customized needs based on their physicochemical properties and preferences.

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