FRM

Foods and Raw Materials, 2021, vol. 9, no. 1

E-ISSN 2310-9599
ISSN 2308-4057

Research Article
Open Access

https://doi.org/10.21603/2308-4057-2021-1-43-51
Available online at http://jfrm.ru/en

Effects of variety and maturity stage of coconut on physicochemical and sensory characteristics of powdered coconut drink

Jeallyza Muthia Azra, Budi Setiawan*, Zuraidah Nasution, Ahmad Sulaeman

IPB University, Bogor, Indonesia

* e-mail: bsetiawan@apps.ipb.ac.id

Received July 10, 2020; Accepted in revised form July 18, 2020; Published online December 15, 2020

Abstract:
Introduction. Coconut water is rich in nutrients and biologically-active compounds. However, it has a short shelf life that can be prolonged by freeze drying. The purpose of this study was to analyze the physicochemical and sensory characteristics of fresh and powdered coconut drinks.
Study objects and methods. The experiments included eight samples, namely fresh and powdered coconut drinks obtained from coconuts of different varieties (tall and hybrid) and maturity stages (4 and 6 m.o.). The samples were analyzed for nutrient content (ash, protein, fat, total carbohydrate, and fiber), physicochemical properties (titratable acidity, pH, viscosity, total soluble solids, turbidity, water activity, and browning index), and sensory characteristics (color, aroma, taste, texture, and overall acceptance).
Results and discussion. The results obtained showed that there were significant differences among the coconut drinks of different varieties and maturity stages. They differed in nutrient content, pH value, titratable acidity, viscosity, and water activity. Meanwhile, the aroma, taste, and overall acceptance scores of all the samples were not significantly different. The powdered drink from 6 m.o. hybrid coconut was selected as the optimal sample due to its good sensory and physicochemical attributes. These attributes were similar to those of the fresh coconut drink.
Conclusion. The powdered drink from 6 m.o. hybrid coconut obtained by freeze drying could be considered as an alternative healthy drink with good quality characteristics.

Keywords: Coconut, coconut water, powder, freeze drying, physicochemical properties, descriptive analysis

Funding: This research was supported by the Directorate of Higher Education, the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia for its Scholarship for Master-to-Doctorate Program for Superior Scholars (No. 142/SP2H/LT/DRPM/2018).

Please cite this article in press as: Azra JM, Setiawan B, Nasution Z, Sulaeman A. Effects of variety and maturity stage of coconut on physicochemical and sensory characteristics of powdered coconut drink. Foods and Raw Materials. 2021;9(1):43–51. https://doi.org/10.21603/2308-4057-2021-1-43-51.

INTRODUCTION

Coconut water has various health benefits, namely it prevents oxidative damage due to its antioxidant content, helps rehydration and supports physical performance, as well as prevents and lowers a high blood pressure [1–3, 5]. Coconut water also has antiobesity and antiinflammatory, antibacterial, antitumour, and antidiabetic effects [5–8]. Young coconut water can reduce insulin levels and plasma glucose in rats fed on fructose [4]. Until now, fresh young coconut water is often consumed to relieve thirst and improve general health. However, coconut water is not easily stored because of its short shelf life. Coconut water is quickly damaged when exposed to the air and heat, so it can lose most of its nutritional and health benefits. In addition, the composition and physicochemical properties of coconut water, namely pH of 5 and water activity of 0.9, makes coconut water a highly preferred medium for microbial growth [9, 10].

There are various kinds of coconut water treatment techniques. At present, the dominant technology is thermal pasteurization, but high temperatures can damage the nutritional content of coconut water and change taste. Such technologies as ultrafiltration and ultraviolet radiation retain nutrients better than pasteurization but reduce the shelf life of products to 15 days at 25°C [11–14].

Freeze drying allows for obtaining dry products with maintained typical properties of raw materials.

Freeze drying has high standards for reliability and control [15]. Furthermore, freeze dried products are easily distributed, stored and consumed. The nutrient content and taste of coconut water powdered by freeze drying are almost similar to those of fresh coconut water [16].

Freeze drying process includes addition of filler or components that increase the stability of the final product and/or improve processing [17]. Coconut meat or flesh after water removal can be converted into value-added products such as a natural filler in coconut drinks. Coconut meat comes from young coconut water that thickens progressively and becomes hard as a result of intense cellular multiplication. The aluminous endosperm or flesh or meat of young coconut is soft, edible, white, and more jelly-like. The flesh is sweet and relatively high in minerals such as iron, zinc, and phosphorus [18].

There has been no published papers on comparing characteristics of fresh coconut drinks and powdered drinks obtained by freeze drying. Therefore, the objective of this study was to analyze effects of the variety and maturity stages on the physicochemical and sensory characteristics of fresh coconut drink and rehydrated coconut drink powdered by freeze drying.

STUDY OBJECTS AND METHODS

The samples of the study were two different varieties of coconut (tall coconut and hybrid coconut) of two maturity ages (4 and 6 m.o.) were selected in PT Perkebunan Nusantara (PTPN) VIII, Citepus Village, Pelabuhan Ratu Sub-district, Sukabumi District, West Java Province, Indonesia. The four-month after-pollination coconuts contained a soft thin layer of coconut flesh, and the six-month, a soft thick layer of coconut flesh. All the chemical reagents used for the chemical analyses were of analytical grade.

On day 3 after purchase, coconut water was manually extracted from the coconut fruit and filtered through a strainer. The coconut meat was scraped off and pooled in a container. The coconut drink consisted of water and meat at a ratio of 2:1. It was then homogenised with a Waring blender at room temperature. The mixture prepared was taken into rectangular plastic containers and kept in a freezer (RSA, Indonesia) at –19°C for 24 h until freezing.

The frozen coconut mixture was dried using a vacuum freeze dryer (LABCONCO) at ≤ 50°C under vacuum pressure below 1.0 mbar for 90 ± 2 h. The dried product had a water activity value of < 0.6, as reported in [19]. The dried mixture was then powdered and stored in a desiccator using zip-lock aluminium pouch until further analysis. It aimed to protect the samples from air contamination and sunlight [9]. Eight coconut drink samples, namely fresh and powdered coconut drinks obtained from four- and six-month tall and hybrid coconut, were examined. The experiments were performed in three replications.

Physicochemical characteristics. Ash content was measured gravimetrically by incinerating the samples in a muffle furnace at 550°C [20].

Fat content was determined by the Soxhlet method with steps following protocol set by a semiautomatic Soxhlet extraction instrument (FOSS, ST 243 Soxtec with CU 2046 Control Unit 230V, China). A slight modification was used, namely fresh coconut drink should be dried with a rotary evaporator (IKA, HB 10) at 60°C and 40 rpm for 72 min.

Nitrogen content was determined by the micro-Kjeldahl method using steps developed by a semiautomatic Kjeldahl analysis set of instruments including the digestor (FOSS, Labtec™ DT208 Digestor, China) and destillator (FOSS, KT 200 Kjeltec™ 230V, China). The distillate was then titrated with 0.1 N HCl, then the percentage of crude protein was taken as N×6.25.

Crude fiber were determined by acid base hydrolysis method according to the protocol set by semiautomatic crude fiber extraction system including cold extraction (Tecator, Fibretec System 1021 Cold Extractor) unit and hot extraction (Tecator, Fibretec System 1020 Hot Extractor) unit. The residue left from acid base hydrolysis was then calculated using this formula:

$$\%\,Crude\ Fiber = \frac{W2-W3}{W1} \times 100 \qquad (1)$$

Total carbohydrate was determined as by the difference between the whole sample weight and the sum of ash, fat, protein, and crude fiber contents in the sample. The yield of sample was about 10% (w/v). The powdered sample was then rehydrated with distilled water with the ratio 1:10 to determine titratable acidity, turbidity, color, water activity, and sensory attributes of the coconut drink. The proximate composition of drink was assessed in the Department of Nutrition Science, Faculty of Human Ecology, IPB University, Indonesia.

Total soluble solids was measured by using a portable refractometer with autocorrection at 20°C and expressed in °Brix.

The pH value of the coconut drink was determined using a digital pH meter (Ohaus Starter 3100, USA).

Titratable acidity was determined by titrimetry according to titratable acidity determination in wine or juice with slight modifications [21]. Ten milliliters of coconut drink was transferred into a 250 mL Erlenmeyer flask, followed by 100 mL of neutralized deionized water. The mixture was dripped with 2–3 drops of 1% phenolphthalein and then titrated with standardized 0.1 N NaOH until a distinct but faint pink was reached (maintained for 30 s). Titratable acidity was expressed as percentage of malic acid (w/v):

$$\mathrm{TA} = \frac{N \times M \times V \times 100}{Vc} \qquad (2)$$

where TA is titratable acidity, *N* is the normality of NaO, *V* is the volume of NaOH, *Vc* is the volume of coconut water added, and *M* is the malic acid factor (67.05).

Turbidity was determined using a Shimadzu spectrophotometer (UV-1800, Nakagyo-ku Kyoto, Japan) at wavelength of 610 nm [22]. Absorbance of the sample was measured in relation to distilled water, and the transmittance and respective turbidity were calculated according to equations:

$$T = 100 \times (10^{-Abs}) \quad (3a)$$

$$Turbidity = 100 - T \quad (3b)$$

where *Abs* is absorbance at wavelength of 610 nm, and *T* is the transmittance at wavelength of 610 nm.

Color (browning index). Ten milliliters of coconut drink was mixed with 10 mL of distilled water and 30 mL of ethanol. The ingredients were then mixed on a magnetic stirring plate (Daihan Science MSH-20D, Korea) at 200 rpm and room temperature for 3 min and then filtered through Whatman paper No. 1. A blank sample with distilled water instead of coconut water was also prepared. Color intensity of the samples was quantified in a spectrophotometer (Shimadzu, UV-1800, Nakagyo-ku Kyoto, Japan) by measuring the filtrate absorbance at 420 nm [23].

Viscosity in fresh coconut drink and rehidrated powdered sample was measured using a viscometer (Brookfield Viscometer model RVT Serial DY300, Stoughton, Ma, USA). All measurements were expressed in centipoises (cP) by using a look-up table known as "the Brookfield Factor Finder" to convert torque reading:

$$Viscosity\ in\ cP(mPa \cdot s) = Dial\ reading\ \times factor \quad (4)$$

The water activity of coconut drinks was measured at 26°C by using a manual water activity meter (Rotronic-Hygrolab) that was calibrated using standard solutions provided by the manufacturer.

Sensory analysis. About 40 semi-trained panelists were involved in sensory analysis as suggested in [24], but only 36 panelists completed it. The tests were applied in individual booths with daylight fluorescent lamps. The coconut drink sample (25 g per sample) was served in plastic cups codified with random three-digit numbers at normal consumption temperature (16–18°C). Water was provided as a palate cleanser. Color, aroma, texture (mouthfeel), taste, and overall acceptance were evaluated by using a nine-point structured hedonic scale from 1 ("disliked extremely") to 9 ("liked extremely") [24, 25].

Descriptive analysis with consensus method according to [26] was also performed with nine trained panelists aged between 24 and 27. The panelists were asked to identify aroma and taste descriptors, as well as their references. A total of 10 mL of the sample was served in a closed plastic cups codified with random three-digit numbers and kept at room temperature. In addition, water, tissue, palate cleanser (plain bread), and a container for spitting were provided. Each panelist assessed the reference and sample intensity on a scale of 0 to 15 across aroma and taste descriptors.

Statistical analysis. Data were reported as the mean ± SD. Analysis of variance (ANOVA) followed by Tukey LSD's test was done using SPSS 16.0 program, with significance established at the $P < 0.05$ level.

RESULTS AND DISCUSSION

Proximate analysis. Contents of fat, ash, protein, fiber, and total carbohydrates are presented in Table 1. They differed significantly in the experimental coconut drinks ($P < 0.05$). The fat content in fresh drinks was 0.57–21.82% (the highest value in six-month hybrid) and 4.85–15.11% in powdered drinks (the highest value in six-month hybrid). Freeze drying process did not affect fat content of the samples. On the other hand, fat content of samples increased following maturity. The fat content in coconut drinks did not depend on the coconut variety. Fat contents in our study were lower than those of coconut milk in [27]. However, they were within the range pointed out by Mahayothee *et al.*, namely, 4.70–24.22% [28]. This difference could be due to the variety and maturity of coconut. The dependence of the fat content on maturity in this study was in line with Mahayothee *et al.* in case of some varieties of coconut in Thailand [28]. The thickness and fat content of coconut meat increased significantly with the maturity ages [28].

The ash content in fresh and powered coconut samples was 6.61–9.62% and 7.33–9.43%, respectively. The 4-month hybrid coconut drinks had the highest

Table 1 The proximate analysis offresh and powdered coconut drinks (mean ± SD)

Sample	Fat, %	Ash, %	Protein, %	Crude fibre, %	Total carbohydrates, %
Tall, 4 mo, fresh	0.57 ± 0.01^{d}	6.61 ± 0.79^{c}	$7.33 \pm 0.10a^{b}$	3.91 ± 0.26^{a}	84.75 ± 0.93^{a}
Tall, 6 mo, fresh	15.29 ± 0.77^{bc}	7.20 ± 0.08^{bc}	8.52 ± 0.16^{bc}	2.06 ± 0.07^{b}	67.79 ± 0.79^{cd}
Hybrid, 4 mo, fresh	1.57 ± 0.00^{d}	9.62 ± 0.10^{a}	12.11 ± 0.08^{a}	3.69 ± 0.65^{a}	76.29 ± 0.18^{b}
Hybrid, 6 mo, fresh	21.82 ± 0.76^{a}	8.38 ± 0.35^{ab}	10.09 ± 0.11^{ab}	4.25 ± 0.21^{a}	61.26 ± 2.05^{e}
Tall, 4 mo, powdered	6.09 ± 1.04^{cd}	7.33 ± 0.51^{bc}	7.43 ± 1.41^{b}	0.81 ± 0.09^{bc}	75.24 ± 2.76^{b}
Tall, 6 mo, powdered	10.33 ± 0.30^{bc}	7.75 ± 0.03^{bc}	6.29 ± 0.02^{b}	1.19 ± 0.15^{bc}	73.56 ± 0.35^{bc}
Hybrid, 4 mo, powdered	4.85 ± 0.87^{cd}	9.43 ± 0.40^{a}	8.89 ± 0.77^{ab}	0.69 ± 0.02^{c}	73.13 ± 0.36^{bc}
Hybrid, 6 mo, powdered	15.11 ± 2.25^{b}	7.65 ± 0.21^{bc}	7.98 ± 0.39^{ab}	1.23 ± 0.23^{bc}	65.01 ± 2.27^{cde}

^{a,b,c,d,e,f} = significantly different ($P < 0.05$)

ash content. There was no dependence of ash contents among samples on freeze drying process and maturity, while the variety made a difference. We found that the hybrid variety had a higher ash content compared to the tall variety. The stable content of ash in this study was within the range mentioned by Santana *et al.*, namely, 0.75–10.72%, and it was by 1.60%, 1.43–2.23%, and 1.05% higher than ash in coconut milk, coconut meat, and coconut haustorium, respectively [27–30]. The differences of the results might be due to the differences of maturity stages and compositions of the samples. There was a tendency to increasing ash contents with maturity in the tall variety. This data was in accordance with Mahayothee *et al.*, who stated that ash in coconut meat increased with maturity stages until 190 d of pollination (DAP) [28].

The protein content of in the fresh and powdered samples accounted for 7.33–12.11% and 6.29–8.89%, respectively, with the highest content in fresh and powdered four-month hybrid. The protein content was not influenced by the freeze drying process, maturity stages, and variety. Protein amounts in coconut drinks in this study were higher than those in fresh coconut milk, coconut meat, and coconut grating by 6.10%, 2.71–4.49%, and 5.59%, respectively [27, 28, 31]. However, it was lower than the protein content in coconut meat (16.0%) according to [32]. This difference could be due to the dominant use of coconut water in this study. The stability of protein content with maturity stages in this study confirmed Mahayothee *et al.* data, who found that the protein content of coconut meat did not increase significantly in coconut aged 180 DAP (6 m.o.) and 190 DAP (6+ m.o.), but it would increase significantly in the samples aged 225 DAP (7+ m.o.) (2.71–4.49%) [28].

The crude fiber in the coconut drinks ranged between 2.06 and 4.25% in the fresh samples and between 0.69 and 1.23% in the powdered samples. The six-month hybrid samples in fresh and powdered forms demonstrated the highest values. The crude fiber of the samples was not influenced by maturity stages and the variety of coconut. Our results were close to fiber contents in coconut milk and coconut meat, which accounted for 3.10% and 0.92–6.51%, respectively [27, 28].

The total carbohydrate content accounted for 61.26–84.75% in the fresh coconut drinks and 65.01–75.24% in the powdered samples, with the highest value in fresh and powdered four-month tall variety. Freeze drying was not proved to decrease the carbohydrate content, while maturity stage decrease it. Additionally, tall coconut demonstrated a higher total carbohydrates than hybrid coconut. The total carbohydrates in our research were lower than those by Santoso *et al.*, who found that carbohydrates in young coconut were 81.8 and 54.9% in coconut water and in coconut meat, respectively [32]. However, our results conformed with those found by Mahayothee *et al.*, who reported that carbohydrate content of coconut meat increased insignificantly from 180 DAP (6 m.o.) until 190 DAP (6+ m.o.) then decreased significantly until 225 DAP (7+ m.o.) [28]. The difference in carbohydrate content might be due to the difference in varieties and land areas of planting. The decreased carbohydrate content might be due to the increase in fat content that occurred in hybrid coconut as well as in tall coconut with time.

Titratable acidity and pH value. The titratable acidity and pH values of fresh and powdered coconut drinks obtained from different coconut varieties were in the range of 0.63–0.91% and 5.56–6.37, respectively (Table 2). They differed among the samples ($P < 0.05$). Younger coconut age showed a tendency to decrease titratable acidity and increase the pH value.

Titratable acidity values in this study were higher than those found by Rattanaburee *et al.*, who reported that the titratable acidity of fresh freeze-dried young coconut juice was 0.016–0.018% [9]. The value of 0.18% (citric acid) was due to the presence of ascorbic acid in tender coconut water [33]. Decreasing titratable acidity with maturity stages was in agreement with Mahayothee *et al.* and Tan *et al.* [28, 34]. This might be due to the decrease of organic acids in coconut drinks with maturity.

The pH value in spray-dried and freeze-dried coconut juice was around 4.87–5.04 and 5.00–5.14, respectively [9, 10]. In this study, pH was slightly higher, which could be due to the addition of coconut meat into the coconut water. The pH value of osmo-dried coconut slices or coconut meat was in the range of 6.32–6.67 but that in coconut sap was slightly higher (7.47) than in our research [35, 36]. An increase in pH value with maturity stages was in agreement with Mahayothee *et al.* and Tan *et al.* [28, 34]. This was appeared to be due to the decrease in titratable acidity along with the increasing maturity of coconut. The titratable acidity was inversely related to the pH value.

Physical analysis. Physical attributes of the fresh and powdered coconut drinks under study are shown in Table 3. Total soluble solids, turbidity, and browning index in fresh and powdered coconut drinks

Table 2 pH value and titratable acidity of fresh and powdered coconut drinks (mean ± SD)

Sample	Titratable acidity, %	pH
Tall, 4 mo, fresh	0.82 ± 0.00^{ab}	5.56 ± 0.02^{d}
Tall, 6 mo, fresh	0.66 ± 0.02^{c}	6.33 ± 0.03^{a}
Hybrid, 4 mo, fresh	0.86 ± 0.02^{ab}	5.80 ± 0.01^{c}
Hybrid, 6 mo, fresh	0.82 ± 0.03^{ab}	6.29 ± 0.03^{a}
Tall, 4 mo, powdered	0.63 ± 0.02^{c}	5.63 ± 0.07^{d}
Tall, 6 mo, powdered	0.78 ± 0.03^{abc}	6.29 ± 0.02^{a}
Hybrid, 4 mo, powdered	0.91 ± 0.06^{a}	6.02 ± 0.00^{b}
Hybrid, 6 mo, powdered	0.75 ± 0.00^{bc}	6.37 ± 0.01^{a}

^{a,b,c,d,e,f} = significantly different ($P < 0.05$)

Table 3 Physical characteristics of fresh and powdered coconut drinks (mean ± SD)

Sample	Total soluble solid, º Brix	Turbidity, %	Browning index	Viscosity, cP	Water activity
Tall, 4 mo, fresh	5.00 ± 0.00^{a}	99.97 ± 0.03^{a}	0.02 ± 0.00^{a}	43.50 ± 1.50^{cd}	0.978 ± 0.00^{a}
Tall, 6 mo, fresh	5.00 ± 0.00^{a}	99.78 ± 0.03^{a}	0.01 ± 0.00^{a}	107.50 ± 2.50^{b}	0.977 ± 0.00^{a}
Hybrid, 4 mo, fresh	5.00 ± 0.00^{a}	99.80 ± 0.05^{a}	0.02 ± 0.00^{a}	19.75 ± 0.25^{e}	0.975 ± 0.00^{a}
Hybrid, 6 mo, fresh	6.00 ± 0.00^{a}	99.72 ± 0.05^{a}	0.02 ± 0.01^{a}	275.00 ± 5.00^{a}	0.978 ± 0.01^{a}
Tall, 4 mo, powdered	5.00 ± 0.00^{a}	99.73 ± 0.05^{a}	0.02 ± 0.00^{a}	36.75 ± 3.25^{d}	0.430 ± 0.01^{b}
Tall, 6 mo, powdered	5.00 ± 0.00^{a}	99.70 ± 0.01^{a}	0.02 ± 0.00^{a}	98.38 ± 1.62^{b}	0.233 ± 0.03^{c}
Hybrid, 4 mo, powdered	5.00 ± 0.00^{a}	99.66 ± 0.06^{a}	0.02 ± 0.00^{a}	54.50 ± 0.50^{c}	0.416 ± 0.00^{b}
Hybrid, 6 mo, powdered	6.00 ± 0.00^{a}	99.83 ± 0.04^{a}	0.29 ± 0.00^{a}	268.00 ± 2.00^{a}	0.409 ± 0.01^{b}

^{a,b,c,d,e,f} = significantly different ($P < 0.05$)

were not significantly different among the samples ($P > 0.05$). There were significant differences in viscosity and water activity among the samples ($P < 0.05$), namely the viscosity increased with increasing maturity stages and in the hybrid variety, and the powdered drinks had a decreased water activity. Maturity stages and the variety of coconut did not influenced the water activity.

Total soluble solids in this study (5.0–6.0°Brix) were slightly lower than those in freeze-dried and spray-dried young coconut juice reported by Rattanaeburee *et al.*, which were in the ranges of 6.25–6.50°Brix and 7.23–7.98°Brix, respectively [9, 10]. The results demonstrated one of the advantages of freeze drying [9]. In addition, total soluble solids did not show any significant changes with increasing coconut maturity, which can be due to young category of the sample used (4 and 6 m.o.). According to data found by Terdwongworakul *et al.*, total soluble solids in young coconut water increased from 5.39 to 6.76°Brix in the immature stage, then increased linearly to 7.45°Brix at the end of the mature stage, and continued rising at a slightly higher rate to 8.24°Brix at the end of the over-mature stage [37]. The solids present in tender coconut water of about 5.3°Brix were mainly soluble solids such as sugars [38].

Turbidity values in fresh and powdered coconut drinks in this study were slightly higher (99.66–99.97%) than those in spray-dried young coconut juice (96.58–97.89%) [10]. Nevertheless, they were within the range of the values in fresh and freeze-dried young coconut juice (97.72–101.61%) [9]. The percentage of flesh or coconut meat in coconut water was assumed to affect adversely the color, which was indicated by the high turbidity in the samples.

The browning index values of the samples were extremely small (0.10–0.29), which showed that freeze drying did not result in browning of the samples. However, samples in other studies experienced browning that might be caused by several factors such as degradation of reducing sugars, Maillard reaction, and degradation of decomposition products of ascorbic acid (hydroxymethylfurfural) during coconut processing [39–41].

Coconut water is categorized as a Newtonian fluid that has the same viscosity at different shear rates. The viscosity value in this study was higher (up to 275.00 cP) than that in tender coconut water at 25°C and 5.3°Brix (62.6 cP) [38]. The tendency of increasing viscosity with maturity stages in the hybrid variety in this study could be due to an increased fiber content in coconut meat, especially in fresh and powdered six-month hybrid coconut, which had the highest total soluble solids. Viscosity in tender coconut water increased significantly with the increase in total soluble solids and decreased with the increase in water activity and temperature. Temperature and total soluble solid concentration were reported to have strong effects on the viscosity of Newtonian fluids [38].

The water activity of the fresh coconut drink under study (0.975–0.978) was within the range of the values in fresh tender coconut water obtained by Manjunatha and Raju, which were beetwen 0.870 and 0.982 [38]. However, the powdered coconut drinks had a slightly higher water activity (0.233–0.430) compared to coconut sugar powder (0.20–0.33), being within the safe limit to prevent damage caused by microorganisms and biochemical reactions (< 0.6) and the critical limit (< 0.7) [42–44].

Just like the water content, there was a tendency of a significant decrease in water activity by freeze drying. Water activity is an important factor affecting the stability of dehydrated products. The reduction in water activity in liquid foods led to better stability, which was a beneficial factor during storage, handling, and transportation of the product [38]. Furthermore, it could reduce costs associated with whole fruit and improve its shelf life. Therefore, water activity is considered as a critical factor that determines the shelf life of food. Water activity in coconut water decreased significantly with the increase in soluble solid content and the increase in viscosity [38].

Sensory analysis. The sensory analysis of the coconut drinks included color, aroma, texture (mouthfeel), taste, and overall acceptance. Subjective organoleptic assessment depends primarily on the sensitivity of the panelist and conditions under which it is carried out [45]. Table 4 demonstrates the mean scores of acceptance sensory analysis of the fresh and powdered coconut drinks.

Table 4 Effect of variety and maturity age of coconut on sensory acceptance of fresh and powdered coconut drinks (mean ± SD)

Sample	Sensory acceptance score				
	Color	Aroma	Texture (mouthfeel)	Taste	Overall aceptance
Tall, 4 mo, fresh	6.31 ± 0.95[ab]	5.58 ± 1.13[a]	5.83 ± 1.23[ab]	5.86 ± 1.44[a]	6.08 ± 1.16[a]
Tall, 6 mo, fresh	6.56 ± 0.94[a]	5.94 ± 1.24[a]	5.06 ± 1.35[b]	5.47 ± 1.63[a]	5.56 ± 1.23[a]
Hybrid, 4 mo, fresh	5.53 ± 1.30[bc]	5.67 ± 1.29[a]	6.11 ± 1.21[a]	5.89 ± 1.12[a]	5.94 ± 1.19[a]
Hybrid, 6 mo, fresh	5.94 ± 1.15[abc]	5.61 ± 1.34[a]	5.25 ± 1.73[ab]	5.39 ± 1.59[a]	5.72 ± 1.23[a]
Tall, 4 mo, powdered	5.91 ± 1.08[abc]	5.26 ± 1.24[a]	5.71 ± 1.27[a]	6.03 ± 1.51[a]	6.12 ± 1.17[a]
Tall, 6 mo, powdered	6.29 ± 1.06[ab]	5.59 ± 1.02[a]	5.18 ± 1.45[b]	5.62 ± 1.18[a]	5.82 ± 1.06[a]
Hybrid, 4 mo, powdered	5.44 ± 1.24[c]	5.12 ± 1.45[a]	5.85 ± 1.31[ab]	5.71 ± 1.73[a]	5.82 ± 1.51[a]
Hybrid, 6 mo, powdered	6.03 ± 1.31[abc]	5.68 ± 1.07[a]	5.74 ± 1.58[ab]	6.26 ± 1.33[a]	6.18 ± 1.17[a]

[a,b,c,d,e,f] = significantly different ($P < 0.05$)

The color of a drink is one of the most important characteristics that determines the customer choice. The color of the coconut drink indicated that six-month tall coconut had the highest score both in fresh and powdered forms (6.56 and 6.29), respectively. Color acceptance tended to increase with the increase in coconut maturity. In spite the fact that the samples' browning index values did not change significantly, this did not affect the acceptance of color by the panelists.

Mouthfeel is a parameter related to rheological viscosity and defined as the mixed experience derived from the sensation on the skin of the mouth after ingestion of food or beverage [33]. The texture (mouthfeel) of the coconut drink considerably depended on the ratio of water to meat during the process, while the variety and maturity stages of coconut did not affect the panelists' preferences. The texture (mouthfeel) score was the highest in four-month fresh hybrid coconut (6.11) and four-month powdered tall coconut (5.71). This high score might be due to the fiber content in coconut meat. Staffolo *et al.* found that yoghurt enriched with fiber had a better mouthfeel [46].

The taste acceptance was not significantly different ($P > 0.05$). It might be due to the total soluble solid value as an indicator of sugar which did not change significantly by freeze drying. In addition, the use of coconut meat in the product formulation, in addition to being used as a natural filler, could also help improve the good taste of coconut drinks. Immature coconut water is a delicious and nutritious drink [47]. However, at maturity, coconut water loses its delicious taste to the advantage of the kernel [48]. Coconut meat contains several sugars such as sucrose, glucose, and fructose which along with organic acids, such as citric acid and malic acid, give a good taste to the coconut drink [32].

Also, there were no significant differences in the panelists' opinions on aroma and overall acceptance. It was revealed that there were no significant changes in the overall acceptance of the fresh and powdered coconut drink. The freeze drying method of processing had been reported by Shukla to preserve the aroma and smell of the product [17].

Descriptive analysis in this study showed that coconut had coconut-like, creamy, nutty, rancid, sweet, and ferment aroma (Fig. 1). The various aromas

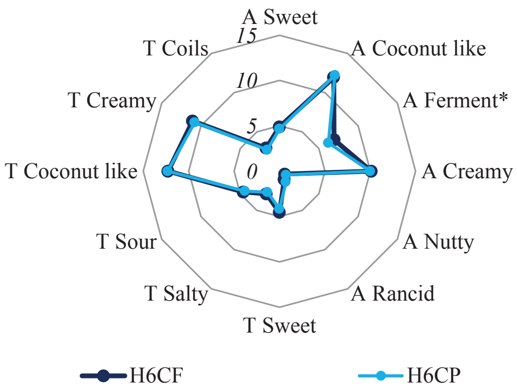

Figure 1 Descriptive analyse of aroma and taste of hybrid six-month coconut drinks

identified are explained by the present of various volatile compounds in coconut water [49]. The tastes identified by the panelists were coconut-like, sweet, sour, acid, salty, and coils. Freeze drying maintained the aroma and taste attributes except ferment aroma and sweet taste ($P < 0.05$).

The results of the descriptive analysis in this study were in line with those in other studies, which revealed that coconuts had fresh coconut, nutty, rancid, and sweet aroma [50, 51]. The decrease in ferment aroma in the coconut drinks after freeze drying was in line with that in coconut water after heat treatment, which could be due to a decrease in acetoin during the processing [52].

The tastes identified by the panelists were in line with the results of other studies, which revealed coconut-like, sweet, acid, and salty tastes [50, 53]. The powdered coconut drinks showed less sweet taste compared to the fresh samples. This could be because of reducing not only water but also sugars in the product by freeze drying. Moreover, rehydrated drinks include mineral water, while fresh coconut drinks contain sweet coconut water. Thus, sweet taste between fresh coconut drinks and powdered ones can be different.

CONCLUSION

There were found significant differences in physicochemical characteristics, such as proximate composition, pH, titratable acidity, viscosity, and water activity among fresh and powdered coconut drinks of different varieties and maturity stages. Meanwhile, aroma, taste, and overall acceptance of all coconut drinks were similar. In the whole, the nutrient content of the hybrid coconut was higher compared to the tall variety, so the powdered six-month hybrid coconut drink was selected for descriptive test. The test showed that freeze drying did not significantly change the sensory properties of the sample, except for ferment aroma. Consequently, powdered six-month hybrid coconut should be further studied because of its good sensory and physical characteristics, as well as nutrient content.

CONTRIBUTION

J.M. Azra contributed to the conception, collected and analyzed data for the work, and wrote the manuscript. J.M. Azra, Z. Nasution, A. Sulaeman, and B. Setiawan designed the work. Z. Nasution and B. Setiawan revised the manuscript for important intellectual content, and B. Setiawan conducted the final revision of the manuscript.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

REFERENCES

1. Geetha V, Bhavana KP, Chetana R, Gopala KAG, Suresh KG. Studies on the composition and in-vitro antioxidant activities of concentrates from coconut testa and tender coconut water. Journal of Food Processing and Technology. 2016;7(5). https://doi.org/10.4172/2157-7110.1000588.
2. Santos JLA, Bispo VS, Filho ABC, Pinto IFD, Dantas LS, Vasconcelos DF, et al. Evaluation of chemical constituents and antioxidant activity of coconut water (*Cocus nucifera* L.) and caffeic acid in cell culture. Annals of the Brazilian Academy of Sciences. 2012;85(4):1235–1246. https://doi.org/10.1590/0001-37652013105312.
3. Kalman DS, Feldman S, Krieger DR, Bloomer RJ. Comparison of coconut water and a carbohydrate-electrolyte sport drink on measures of hydration and physical performance in exercise-trained men. Journal of the International Society of Sports Nutrition. 2012;9. https://doi.org/10.1186/1550-2783-9-1.
4. Bhagya D, Prema L, Rajamohan T. Therapeutic effects of tender coconut water on oxidative stress in fructose fed insulin resistant hypertensive rats. Asian Pacific Journal of Tropical Medicine. 2012;5(4):270–276. https://doi.org/10.1016/S1995-7645(12)60038-8.
5. Mohamad NE, Yeap SK, Ky H, Ho WY, Boo SY, Chua J, et al. Dietary coconut water vinegar for improvement of obesity-associated inflammation in high-fat-diet treated mice. Food and Nutrition Reseaarch. 2017;61. https://doi.org/10.1080/16546628.2017.1368322.
6. Rukmini JN, Manasa S, Rohini C, Sireesha LP, Ritu S, Umashankar GK. Antibacterial efficacy of tender coconut water (*Cocos nucifera* L) on *Streptococcus mutans*: An *in-vitro* study. Journal of International Society of Preventive and Community Dentistry. 2017;7(2):130–134. https://doi.org/10.4103/jispcd.JISPCD_275_16.
7. Mohamad NE, Yeap SK, Abu N, Lim KL, Zamberi NR, Nordin N, et al. *In vitro* and *in vivo* antitumour effects of coconut water vinegar on 4T1 breast cancer cells. Food and Nutrition Research. 2019;63. https://doi.org/10.29219/fnr.v63.1616.
8. Pinto IFD, Silva RP, Chaves AD, Dnatas LS, Bispo VS, Matos IA, et al. Study of antiglycation, hypoglycemic, and nephroprotective activities of the green dwarf variety coconut water (*Cocos nucifera* L.) in alloxan-induced diabetic rats. Journal of Medicinal Food. 2015;18(7):802–809. https://doi.org/10.1089/jmf.2014.0046.
9. Rattanaburee P, Amnuaikit T, Radenahmad N, Puripattanavong J. Phytochemical study and its quantity and quality of fresh and freeze-dried young coconut juice (*Cocos nucifera* L.). Advanced Materials Research. 2014;884–885:490–493. https://doi.org/10.4028/www.scientific.net/AMR.884-885.490.
10. Rattanaburee P, Amnuaikit T, Puripattanavong J. Physicochemical properties of spray-dried young coconut juice. International Journal of Pharma Medicine and Biological Sciences. 2017;6(2):43–47. https://doi.org/10.18178/ijpmbs.6.2.43-47.
11. Augusto PED, Ibarz R, Garvin A, Ibarz A. Peroxidase (POD) and polyphenol oxidase (PPO) photo-inactivation in a coconut water model solution using ultraviolet (UV). Food Research International. 2015;74:151–159. https://doi.org/10.1016/j.foodres.2015.04.046.
12. Cappelletti M, Ferrentino G, Endrizzi I, Aprea E, Betta E, Corollaro ML, et al. High pressure carbon dioxide pasteurization of coconut water: A sport drink with high nutritional and sensory quality. Journal of Food Engineering. 2015;145:73–81. https://doi.org/10.1016/j.jfoodeng.2014.08.012.
13. Gautam D, Umagiliyage AL, Dhital R, Joshi P, Watson DG, Fisher DJ, et al. Nonthermal pasteurization of tender coconut water using a continuous flow coiled UV reactor. LWT – Food Science and Technology. 2017;83:127–131. https://doi.org/10.1016/j.lwt.2017.05.008.

14. Kailaku SI, Setiawan B, Sulaeman A. Pengaruh proses membran ultrafiltrasi dan ultraviolet terhadap komposisi gizi, sifat fisikokimia dan organoleptik minuman air kelapa [The effects of ultrafiltration and ultraviolet process on nutritional composition, physicochemical and organoleptic properties of coconut water drink]. Jurnal Penelitian Tanaman Industri [Industrial Crops Research Journal]. 2016;22(1):43–51. (In Indonesian). https://doi.org/10.21082/littri.v22n1.2016.43-51.

15. Ciurzynska A, Lenart A. Freeze-drying – application in food processing and biotechnology – a review. Polish Journal Food Nutrition Sciences. 2011;61(3):165–171. https://doi.org/10.2478/v10222-011-0017-5.

16. Boonnumma S, Chaisawadi S, Suwanyuen S. Freeze-dried coconut water powder processing for natural health drink. Acta Horticulturae. 2014;1023:91–94. https://doi.org/10.17660/ActaHortic.2014.1023.12.

17. Shukla S. Freeze drying process: a review. International Journal of Pharmaceutical Sciences and Research. 2011;2(12):3061–3068. https://doi.org/10.13040/IJPSR.0975-8232.2(12).3061-68.

18. Silva PSA, Bamunuarachchi A. Manufacture of carbonated tender coconut water and development of a process for the utilization of coconut flesh. Asian Journal of Food and Agro-Industry. 2009;2(02):210–213.

19. Roongruangsri W, Bronlund JE. Effect of air-drying temperature on physico-chemical, powder properties and sorption characteristics of pumpkin powders. International Food Research Journal. 2016;23(3):962–972.

20. Official methods of analysis of AOAC International, 18th Edition. Washington: The Association of Official Analytical Chemists; 2006.

21. Official methods of analysis of AOAC international. 16th ed. Washington: Association of Official Analytical Chemists; 1995.

22. Campos CF, Souza PEA, Coelho JV, Gloria MBA. Chemical composition, enzyme activity and effect of enzyme inactivation on flavor quality of green coconut water. Journal Food of Processing Preservation. 1996;20(6):487–500. https://doi.org/10.1111/j.1745-4549.1996.tb00761.x.

23. Rattanathanalerk M, Chiewchan N, Srichumpoung W. Effect of thermal processing on the quality loss of pineapple Juice. Journal of Food Engineering. 2005;66(2):259–265. https://doi.org/10.1016/j.jfoodeng.2004.03.016.

24. Meilgaard MC, Carr BT, Civille GV. Sensory evaluation techniques. 5ed. Boca Raton: CRC Press; 2016. 326 p.

25. Pimentel TC, da Cruz AG, Deliza R. Sensory evaluation: sensory rating and scoring methods. In: Caballero B, Finglas PM, Toldrá F, editors. Encyclopedia of food and health. Academic Press; 2016. pp. 744–749. https://doi.org/10.1016/B978-0-12-384947-2.00617-6.

26. Chambers E. Consensus methods for descriptive analysis. In: Kemp SE, Hort J, Hollowood T, editors. Descritptive analysis in sensory evaluation. West Sussex: John Wiley and Sons; 2018. pp. 211–236. https://doi.org/10.1002/9781118991657.ch6.

27. Rehman S, Ahmad MM, Yameen A, Almas K, Muntaha S. Sensory and nutritional evaluation of coconut-natural milk blend. Pakistan Journal of Life and Social Sciences. 2004;2(2):104–108.

28. Mahayothee B, Koomyart I, Khuwijitjaru P, Siriwongwilaichat P, Nagle M, Muller J. Phenolic compounds, antioxidant activity, and medium chain fatty acids profiles of coconut water and meat at different maturity stages. International Journal of Food Properties. 2016;19(9):2041–2051. https://doi.org/10.1080/10942912.2015.1099042.

29. Santana IA, Ribeiro EP, Iguti AM. Evaluation of green coconut (*Cocos nucifera* L.) pulp for use as milk, fat and emulsifier replacer in ice cream. Procedia Food Science. 2011;1:1147–1453. https://doi.org/10.1016/j.profoo.2011.09.214.

30. Manivannan A, Bhardwaj R, Padmanabhan S, Suneja P, Hebbar KB, Kanade SR. Biochemical and nutritional characterization of coconut (*Cocos nucifera* L.) haustorium. Food Chemistry. 2018;238:153–159. https://doi.org/10.1016/j.foodchem.2016.10.127.

31. Lamdande AG, Prakash M, Raghavarao KSMS. Storage study and quality evaluation of fresh coconut grating. Journal of Food Processing and Preservation. 2017;42(1). https://doi.org/10.1111/jfpp.13350.

32. Santoso U, Kubo K, Ota T, Tadokoro T, Maekawa A. Nutrient composition of *kopyor* coconuts (*Cocos nucifera* L.). Food Chemistry. 1996;57(2):299–304. https://doi.org/10.1016/0308-8146(95)00237-5.

33. Gangwar AS, Bhardwaj A, Vasudha S. Fermentation of tender coconut water by probiotic bacteria *Bacillus coagulans*. International Journal of Food Studies. 2018;7:100–110. https://doi.org/10.7455/ijfs/7.1.2018.A9.

34. Tan T-C, Cheng L-H, Bhat R, Rusul G, Easa AM. Composition, physicochemical properties and thermal inactivation kinetics of polyphenol oxidase and peroxidase from coconut (*Cocos nucifera*) water obtained from immature, mature, and overly-mature coconut. Food Chemistry. 2014;142:121–128. https://doi.org/10.1016/j.foodchem.2013.07.040.

35. Jariyawaranugoon U. Evaluation of pretreatment on osmo-dried coconut properties and its impact on quinoa dessert. Journal of Food Science. 2018;2(3):287–293.

36. Nurhadi B, Sukri N, Sugandi WK, Wirdanti AP, Restiani R, Noflianrini Z, et al. Comparison of crystallized coconut sugar produced by traditional method and amorphous coconut sugar formed by two drying methods: vacuum drying and spray drying. International Journal of Food Properties. 2018;21(1):2339–2354. https://doi.org/10.1080/10942912.2018.1517781.
37. Terdwongworakul A, Chaiyapong S, Jaripomas B, Meeklangsaen W. Physical properties of fresh young Thai coconut for maturity sorting. Biosystems Engineering. 2009;103(2):208–216. https://doi.org/10.1016/j.biosystemseng.2009.03.006.
38. Manjunatha SS, Raju PS. Modelling the rheological behaviour of tender coconut (*Coconut nucifera* L) water and its concentrate. International Food Research Journal. 2013;20(2):731–743.
39. Ibarz A, Paga NJ, Garza S. Kinetic models for colour changes in pear puree during heating at relatively high temperatures. Journal of Food Engineering. 1999;39(4):415–422. https://doi.org/10.1016/S0260-8774(99)00032-1.
40. Yaylayan V. In search of alternative mechanisms for the Maillard reaction. Trends in Food Science and Technology. 1990;1:20–22. https://doi.org/10.1016/0924-2244(90)90006-K.
41. Solomon O, Svanberg U, Sahlstro MA. Effect of oxygen and fluorescent light on the quality of orange juice during storage at 8ºC. Food Chemistry. 1995;53(4):363–368. https://doi.org/10.1016/0308-8146(95)99828-N.
42. A-sun K, Thumthanaruk B, Lekhavat S, Jumnongpon R. Effect of spray drying conditions on physical characteristics of coconut sugar powder. International Food Research Journal. 2016;23(3):1315–1319.
43. Kha TC, Nguyen MH, Roach PD. Effects of spray drying conditions on the physicochemical and antioxidant properties of the Gac (*Momordica cochinchinensis*) fruit aril powder. Journal of Food Engineering. 2010;98(3):385–392. https://doi.org/10.1016/j.jfoodeng.2010.01.016.
44. Carter BP, Galloway MT, Campbell GS, Carter AH. The critical water activity from dynamic dewpoint isotherms as an indicator of pre-mix powder stability. Journal of Food Measurement and Characterization. 2015;9(4):479–486. https://doi.org/10.1007/s11694-015-9256-1.
45. King BM, Arents P. Measuring sources of error in sensory texture profiling of ice cream. In: Gacula MC, editors. Descriptive sensory analysis in practice. Trumbull: Food and Nutrition Press; 1997. pp. 201–217.
46. Dello Staffolo M, Bertola N, Martino M, Bevilacgua A. Influence of dietary fiber addition on sensory and rheological properties of yogurt. International Dairy Journal. 2004;14(3):263–268. https://doi.org/10.1016/j.idairyj.2003.08.004.
47. Jackson JC, Gordon A, Wizzard G, McCook K, Rolle R. Changes in the chemical composition of coconut (*Cocos nucifera*) water during maturation of the fruit. Journal of the Science of Food Agriculture. 2004;84(9):1049–1052. https://doi.org/10.1002/jsfa.1783.
48. Jayalekshmy A, Arumughan C, Narayanan CS, Mathew AG. Changes in the chemical composition of coconut water during maturation. Journal of Food Science and Technology. 1986;23(4):203–207.
49. De Marchi F, Aprea E, Endrizzi I, Charles M, Betta E, Corollaro ML, et al. Effects of pasteurization on volatile compounds and sensory properties of coconut (*Cocos nucifera* L.) water: thermal vs. high-pressure carbon dioxide pasteurization. Food and Bioprocess Technology. 2015;8(7):1393–1404. https://doi.org/10.1007/s11947-015-1501-4.
50. Ferrentino G, Belscak-Cvitanovic A, Komes D, Spilimbergo S. Quality attributes of fresh-cut coconut after supercritical carbon dioxide pasteurization. Journal of Chemistry. 2013;2013. https://doi.org/10.1155/2013/703057.
51. Wattanapahu S, Suwonsichon T, Jirapakkul W, Kasermsumran S. Categorization of coconut milk products by their sensory characteristics. Kasetsart Journal – Natural Science. 2012;46(6):944–954.
52. Nasution Z, Jirapakkul W, Lorjaroenphon Y. Aroma compound profile of mature coconut water from tall variety through thermal treatment. Journal of Food Measurement and Characterization. 2018;13(1):277–286. https://doi.org/10.1007/s11694-018-9942-x.
53. Assa RR, Prades A, Konan AG, Nemlin J, Konan J-L. Sensory evaluation and sugars contents of coconut (Coconut nucifera L.) water during nuts ripening. African Journal of Food Science. 2013;7(7):186–192. https://doi.org/10.5897/AJFS2012.0601.

ORCID IDs
Jeallyza Muthia Azra https://orcid.org/0000-0002-2749-4026
Budi Setiawan https://orcid.org/0000-0001-8655-5477
Zuraidah Nasution https://orcid.org/0000-0001-8307-1012
Ahmad Sulaeman https://orcid.org/0000-0002-9618-7214